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Stock status and indicators for the lobster fishery in Lobster Fishing Area 34

État des stocks de homard et indicateurs pour la pêche dans la zone 34

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ABSTRACT

Lobster Fishing Area (LFA) 34, off Southwest Nova Scotia encompasses 21,000km^2 and has the highest landings of any LFA in Canada, accounting for 40% of Canadian landings and 23% of the world landings of *Homarus* sp. The fishery is undertaken by 937 Category A vessel based licenses and 30 Commercial Communal based licences (First Nations). The fishery is managed by input controls including a minimum carapace length (CL), prohibition on landing berried females, limited entry, a season between the last Monday in November through to May 31st, and a trap limit of 375 from November to March and 400 from March to May. This assessment is the first time indicators have been used to assess this fishery. Abundance indicators for legal size lobster which include landings, catch rate and scallop survey data are primarily positive. Landings in LFA 34 as a whole continue to be above long-term means but peaked in the 2001-02 season. Landings in sub-areas of LFA 34 ("Grid Groups") generally followed the pattern of the LFA as a whole. A notable exception was in a traditional nearshore ground (Grid Group 2a, Lobster Bay) which has declined 20% from the mean of the reference period (1998-99 to 1999-00) due to a shift in fishing effort away from this area (see below). Catch rates (CPUE) based on Lobster Catch and Settlement Reports (LFA 34 log books) throughout LFA 34 and on Fishermen and Scientist Research Society (FSRS) data (Grid Groups 2a and 2b) were also generally higher relative to the reference period but peaked between 2002-03 and 2003-04 depending on Grid Group. Fishing pressure indicators showed either increased pressure or no change. A shift in effort away from traditional nearshore grounds is indicated by a decline in numbers of trap hauls in the nearshore Grid Groups 1 and 2a and an increase in number of trap hauls in all other Grid Groups. The increase in fishing pressure in midshore and offshore portions of LFA 34 raises a conservation concern because these grounds have historically supported larger lobsters. Relative to the reference period (1998-2000), the stock is still fished at high levels with estimates for exploitation in nearshore areas (2a and 2b) on the order of 70% and higher. Production indicators showed either no changes or were positive in relation to the reference period. Pre-recruit abundance in a nearshore portion of LFA 34 (Grid Groups 2a and 2b) in fall, based on CPUE in FSRS traps, continues to be high but has trended downwards in the last one to two years to be at the level of the reference period. The limited number of indicators for berried females shows no change from the reference period. An ecosystem indicator (mean ocean bottom temperatures) fell by about 2.5°C from 1999-00 to 2003-04 and recovered by 1°C in 2004-05.

RÉSUMÉ

La zone de pêche du homard (ZPH) 34, au large du sud-ouest de la Nouvelle-Écosse, a une superficie de 21 000 km^2 et produit les plus hauts débarquements de toutes les ZPH du Canada, soit 40 % des débarquements canadiens et 23 % des débarquements mondiaux de l'espèce *Homarus*. La pêche y est pratiquée en vertu de 937 permis de bateau de catégorie A et de 30 permis communautaires (Premières nations). Elle est assujettie à des mesures de gestion des intrants, soit une longueur de carapace (LC) minimale, l'interdiction de débarquer des femelles oeuvées, un accès limité, une saison de pêche allant du dernier lundi de novembre au 31 mai de l'année suivante et un nombre de casiers limité à 375 de novembre à mars et à 400 de mars à mai. Dans la présente évaluation, on utilise pour la première fois des indicateurs afin d'analyser la pêche. Les indicateurs de l'abondance des homards de taille réglementaire, comprenant les débarquements, les taux de prises et les données du relevé sur le pétoncle, sont essentiellement positifs. Les débarquements de l'ensemble de la ZPH 34 continuent de se situer au-dessus de la moyenne à long terme, mais ils ont culminé au cours de la saison 2001-2002. Les débarquements dans les secteurs de quadrillage de la ZPH 34 (« groupes de grilles ») suivaient généralement la même tendance que dans l'ensemble de la ZPH 34, avec une nette exception sur les fonds de pêche côtiers traditionnels (secteur de quadrillage 2a, baie Lobster), où ils ont diminué de 20 % par rapport à la moyenne de la période de référence (de 1998-1999 à 1999-2000) en raison d'une réorientation de l'effort de pêche vers d'autres eaux (voir plus loin). Les taux de prises (PUE) fondés sur les Rapports de prises et de transactions concernant le homard (journaux de bord de la ZPH 34) de toute la ZPH 34 et sur les données de la Fishermen and Scientist Research Society (FSRS) (secteurs de quadrillage 2a et 2b) étaient aussi généralement plus élevés que durant la période de référence, mais, selon le secteur de quadrillage, ils culminaient soit en 2002-2003, soit en 2003-2004. Les indicateurs de la pression de pêche dénotaient soit une hausse, soit une absence de changement. Une réorientation de l'effort au détriment des fonds de pêche côtiers traditionnels se reflète dans un déclin du nombre de casiers levés dans les secteurs de quadrillage 1 et 2a, qui sont proches de la côte, et une hausse du nombre de casiers levés dans tous les autres secteurs de quadrillage. L'accroissement de la pression de pêche dans les secteurs semi-côtiers et hauturiers de la ZPH 34 soulève des inquiétudes pour la conservation, car on trouvait jusqu'ici sur ces fonds de plus gros homards. Par rapport à la période de référence, le stock reste très exploité et les estimations du taux d'exploitation dans les secteurs côtiers (2a et 2b) sont de l'ordre de 70 % ou plus. Les indicateurs de production étaient soit inchangés, soit positifs par rapport à la période de référence. D'après les PUE dans les casiers de la FSRS, l'abondance des prérecrues dans des parties côtières de la ZPH 34 (secteur de quadrillage 2a et 2b) en automne continue d'être élevée, mais elle a amorcé une tendance à la baisse depuis un ou deux ans, et elle maintenant la même que pendant la période de référence. Les quelques indicateurs au sujet des femelles oeuvées ne présentaient pas de changement par rapport à la période de référence. Un indicateur écosystémique, (température moyenne au fond), a chuté d'environ 2,5 °C entre 1999-2000 et 2003-2004, puis a remonté de 1 °C en 2004-2005.

1. INTRODUCTION

Lobster Fishing Area (LFA) 34, off Southwest Nova Scotia (Fig. 1.1) encompasses 21,000km^2 and has the highest landings of any LFA in Canada, accounting for 40% of Canadian landings and 23% of the world landings of *Homarus* sp.

The fishery is undertaken by 937 Category A vessel based licenses and 30 Commercial Communal based licences (First nations). The fishery is managed by input controls including a minimum size carapace length (CL), prohibition on landing berried females, limited entry, a season between the last Monday in November through to May 31st, and a trap limit of 375 from November to March and 400 from March to May. The history of regulations in LFA 34 are summarised in Appendix 1.

Season:	Last Monday in November- May 31st
Minimum Legal Size:	82.5mm CL
Trap Limit:	375, 1st day of season - March 31st 400, April 1st - May 31st
No. Licences:	937 Category A (full time) licenses 30 Commercial Communal licences

Fishing prior to the early 1980s occurred on traditional nearshore grounds but has since expanded to include the entire LFA. A unique feature of LFA 34 and other Gulf of Maine lobster fisheries is the presence of a deepwater component due to the warm year-round bottom temperatures in the basins of the Gulf of Maine and along the upper continental slope.

The offshore lobster fishery (LFA 41) established in 1972, fishes from the 50 nautical mile line (92km) to the upper continental slope. Beginning in the late 1970s a few inshore vessels in LFA 34 began to expand out from the traditional nearshore grounds (<55m depth) and fished German and Browns Bank and the Tusket Basin. By the mid 1980s approximately 100 vessels were fishing this deepwater area referred to as the midshore (Duggan and Pezzack 1995). This number remained relatively constant into the mid 1990s. In recent years there have been an increasing number of new larger vessels capable of fishing further from shore and in almost any weather.

1.1. Species Biology

Nova Scotia lobsters take seven to eight years to reach the legal size of 82.5mm CL. At that size they weigh 0.45kg (one pound) and molt once a year. Larger lobsters molt less often, with a 1.4kg (three pound) lobster molting every two to three years. Off southwestern Nova Scotia most lobsters mature between 95 and 100mm CL at an average weight of 0.7kg (1.5lb). The mature female mates after molting in midsummer and the following summer produces eggs that attach to the underside of the tail. The eggs are carried for 10-12 months and hatch in July or August. The larvae spend 30-60 days feeding and growing near the surface before settling to the bottom and seeking shelter. For the first few years lobsters remain in or near their shelter to avoid being eaten. As they grow, they spend more time outside the shelter.

Lobsters seasonally migrate to shallower waters in summer and deeper waters in winter. Over most of the lobster's range these movements amount to a few kilometers however in the Gulf of Maine, the offshore regions of the Scotian Shelf and off New England, lobsters can undertake long distance migrations of 10s to 100s of kilometers.

Current thinking is that the Gulf of Maine lobster population can be viewed as a stock complex, which means that there are a number of sub-populations linked in various ways by movements of larvae and adults. The number and distribution of these subpopulations remains unknown.

1.2. Recent Management Issues

A major conservation management program was initiated in Atlantic Canada in light of the October 1995 review of the Atlantic lobster fishery by the Fisheries Resource Conservation Council (FRCC, 1995). In their report, the FRCC concluded that under the current management regimes, lobster fishermen generally were "taking too much, and leaving too little". Based on the scientific data available to the Council, they concluded that Atlantic lobster fisheries had high exploitation rate and harvested primarily immature animals, resulting in very low levels of eggs-per-recruit (estimated to be as low as one to two percent of what might be expected in an unfished population). While they accepted that lobster stocks have traditionally been quite resilient, they concluded that the risk of recruitment failure was unacceptably high and suggested a need to increase egg production.

Based on the recommendations of the FRCC, a long-term management strategy was developed in consultation with area fishermen with a 4 year plan of conservation measures (1998-2002) aimed at doubling the eggs per recruit. In 2002, a three year conservation Harvesting Plan was proposed by industry and accepted by DFO.

The management changes introduced from 1998 to 2002 to improve conservation were:

- LFA 34 log books recording landings, effort and location by 10 minute grids (1998-99)
- Voluntary v-notching (1998)
- Minimum size increase from 81mm CL to 82.5mm CL (winter/spring of-2000 though not in fully implemented until fall 2000)
- Requirement to release one and no clawed females (cull) (2002)

This report has the following objectives:

- Evaluate 2004 stock status of lobster stocks in LFA 34
- Recommend indicators for monitoring the future health of lobster stock

The status of the lobster stocks in LFA 34 was last assessed by Pezzack et al. (2001). Among the conclusions were that the fishery was experiencing record landings, that there were high exploitation rates and that as a result of v-notching and a minimum size increase (81mm CL to 82.5mm CL) eggs-per-recruit (E/R) had increased by 25-35%. The gains in E/R due to v-notching could not be evaluated because it is a voluntary measure and the actual level of v-notching cannot be accurately determined. Reported levels of v-notching in the LFA 34 log books has steadily declined since 2001. The new management measure in the 2001 Conservation Harvesting Plan (CHP) to return culls (lobster with only one or no claws) is thought to have had a very small effect on egg production, but its exact value cannot be evaluated because cull return rates cannot be tracked.

The fishery presently operates under the 2001-2004 CHP, which needs to be reviewed and updated. The Report of the Lobster Conservation Working Group (DFO 2001) supported the goals of increased eggs-per-recruit, but strongly recommended the development of data-intensive indicators to evaluate the stock and fishery. The Lobster Conservation Working Group and Scotia-Fundy Region's Lobster Conservation Strategy, recommended that within each LFA, indicators be developed that are supported by a broad representation of stakeholders. The purpose of this review is to evaluate the 2004 stock status of lobster stocks in LFA 34 and recommend an assessment framework, including indicators for monitoring the health of the lobster stock, to guide future assessments.

1.3. Indicators

Four general categories of Indicators are developed here:

- Abundance (legal sizes)
- Fishing pressure
- Production/recruitment
- Ecosystem/environment (not presented in this document)

2. DATA DESCRIPTION

2.1. Landings Data

Landings data from 1892 to 1946 are derived from historic records. These data are by calendar year and are summarized by county. Landings from 1947 to 1995 are based on sales slip information from buyers and are summaries by Statistical District (Fig. 2.1). The mandatory catch reporting system changed in 1995 from a system based on dealer sales slips to one based on individual fishermen sending in monthly catch settlement reports. For all LFA's, the catch settlement report only provided information on daily catch by port and date of landing. Thus, landings data were reported by LFA or Statistical District. In November 1998, as part of their lobster conservation plan, LFA 34 fishermen adopted an expanded catch settlement reporting system, called the Lobster Catch and Settlement Report which required them to provide information on daily catch and effort by reference to a 10 min x 10 min grid system (Fig. 2.2). This provided the first picture of landings and effort distribution in LFA 34.

Landings from other regions in Canada and USA landings are based on data provided by regional biologist and state landings posted on Government web sites.

Lobster landings data from 1989 to 1998 were accessed from Oracle database tables created by DFO's Marine Fisheries Division from data compiled by DFO Statistics Branch into the ZIFF (Zonal Interchange File Format) database. The ZIFF database includes lobster landings by Statistical District, port and date in a series of tables aggregated by year since 1989 (called Identified_catches_YYYY). As of 1998, lobster landings were accessed from archived and production components of the MARFIS (Maritime Fishery Information System) database. Data sources prior to 1989 were obtained from Statistics Canada (1892-1976) and the DFO Statistics Branch, Halifax and are summarised in Williamson, 1992.

Changes in reporting systems in 1996 and 1998 may influence accuracy and completeness of landings. Landings prior to 1996, based on sales slips, may have missed a portion of the catch sold directly to consumers or sold directly in the USA. The size of the underestimation is not known. Post 1996 landings, reported by fishermen directly, should be more complete however no analysis has been done to determine completeness or accuracy of reports. Thus changes observed since 1996 must be viewed in light of the change in reporting methods.

2.1.1. Grid Landings

Data from the 1998-2005 Lobster Catch and Settlement Reports (LFA 34 log books) has been edited to produce two data sets. Set 1 contains only those records with complete effort and location information which are used in calculation of landings by grid and Grid Group catch rate and effort. Set 2 contains all records with a reported catch and is used to calculate total landings for LFA 34.

Grids were formed into a total of 9 Grid Groups (Fig. 2.3). Grid Groups were based on depth of water to give a nearshore, a midshore and an offshore area. These where further divided into northern and southern components. Additional subdivisions (A and B) of Grid Groups 2 and 4 were based on known size differences and the history of fishery. For some analyses these subgroups are combined.

2.2. Within-year Fishing Periods: Fall, Winter, Spring

Each fishing season was divided into three major periods:

1. **Fall** – Season start to December 31,
2. **Winter** – January 1st to March 31st and
3. **Spring** – April 1st to May 31st (or end of season).

For some analyses the fall period was further subdivided into the first 2 weeks of the season (1A) and the remainder of the fall period (1B).

2.3. At-sea Samples of the Commercial Catch

At-sea samples collect information from fishermen's catch during normal commercial fishing operations. The data collected includes: carapace length measured to the nearest millimetre (from the back of eye socket to the end of the carapace), sex, egg presence and stage, shell hardness, occurrence of culls and v-notches, and number, location and depth of traps. Since 1988 all data is georeferenced with latitude and longitude.

At-sea sampling provides detailed information on lobster size-structure in the traps (including sub-legal, berried, and soft-shelled lobsters). As all lobsters retained in each trap haul are measured, the numbers caught can be converted into estimates of the catch rate of legal-sized animals by weight from known length-weight relationships.

Prior to 1999, data was obtained through at-sea sampling conducted during the second to fourth weeks of the fall season, and the last 3 weeks of the spring season. Although the time of sampling has remained relatively consistent, the number of areas and level of sampling has varied considerably over time (Fig. 2.4). Sampling effort was high in 1985-86 with 21 samples, and between 11-15 samples per season from 1987 to 1993. The sample number was further reduced during 1993-1995, as a result of budget constraints to

6-7 samples seasonally with greater emphasis placed on the springtime. During 1995-1997, the lowest level of sampling was reached with only 3 spring samples achieved.

In the 1998 stock assessment (Pezzack, Lawton *et al.* 1999) it was acknowledged that the existing scale of catch sampling undertaken in the lobster fishery was grossly inadequate for the derivation of general estimates of the catch size structure. Substantial effort has been undertaken since the last assessment to expand the capability to obtain, access, and interpret at-sea sampling data.

Sampling of the midshore fishery, deeper than 30 fathoms, has historically been sporadic. This is in part due to the higher cost associated with the longer midshore trips, fishing effort taking place outside of the traditional sampling periods and in mid winter, the variability of times when vessels fish specific areas and the difficulty caused by short notice of sailing in the mid-winter period.

In 1999-00 at-sea sampling effort was expanded to cover all of LFA 34 and over 90 samples were collected during the season including opening week of the season (Fig. 2.5). The spatial and temporal distribution of the samples were based on the results of the new LFA 34 log book introduced in 1998-99 which provided daily information on catch and effort by 10 min squares (Fig. 2.2). The LFA was divided into sampling areas based on location and depth and sample numbers per month assigned based on the landings from those areas the previous year. This gives more emphasis to the areas with higher landings where variation may be greater. It was however recognised that the deepwater areas of the midshore are a region of special interest and importance, so additional samples were assigned to these areas.

2.4. FSRS Recruitment Traps

The Fishermen and Scientists Research Society (FSRS) recruitment trap project involves volunteer fishermen keeping track of the lobsters caught in project traps. Fishermen participants use standard traps and a standard gauge to assign each lobster captured to a size group. Size groups (as of fall 2003) are listed below:

Size 1 (less than 11mm)
Size 2 (11mm – 20.9mm)
Size 3 (21mm – 30.9mm)
Size 4 (31mm – 40.9mm)
Size 5 (41mm – 50.9mm)
Size 6 (51mm – 60.9mm)
Size 7 (61mm – 70.9mm)
Size 8 (71mm – 75.9mm)
Size 9 (76mm – 80.9mm)
Size 10 (81mm – 90.9mm)
Size 11 (91mm – 100.9mm)
Size 12 (101mm – 110.9mm)
Size 13 (111mm – 120.9mm)
Size 14 (121mm – 130.9mm)
Size 15 (greater than 131mm)

Size groups 8 and 9 are in 5mm increments to give a clear indication of the number of lobsters just under the legal size limit. Fishermen also record whether the lobster is legal sized, its sex and the presence of eggs.

Prior to 2003 the size groups ran from size 1 (less than 51mm) to size 8 (101mm and greater). Fishermen participants use standard traps and a standard gauge to assign each lobster captured to a size group. Size groups are listed below:

Size 1 (less than 51mm)
Size 2 (51mm – 60.9mm)
Size 3 (61mm – 70.9mm)
Size 4 (71mm – 75.9mm)
Size 4.1 (sublegal lobsters 71mm – 75.9mm)
Size 4.0 (legal lobsters 71mm – 75.9mm)
Size 5 (76mm – 80.9mm)
Size 6 (81mm – 90.9mm)
Size 6.1 (sublegal lobsters 81 – 90.9mm)
Size 6.0 (legal lobsters 81-90.9mm)
Size 7 (91mm – 100.9mm)
Size 8 (101mm and greater)

Within LFA 34 the number of project participants has grown from 3 in 1998-99 to 45 in 2004-05 (Table 2.5.1). Most of these traps are set within Grid Groups 1, 2a and 2b. In 2004-05 there were 1637 project trap hauls in Grid Group 1, 1289 in Grid Group 2a and 1622 in Grid Group 2b (Table 2.5.2).

2.5. Scallop Survey

Surveys with scallop drags are conducted annually to assess sea scallop abundance. These surveys started in the Bay of Fundy in 1981 and in 1991 were extended into the areas now delineated as Grid Groups 1, the western portion of 2a and 3 in LFA 34. Full comparable coverage of these areas and the northern portion of 4a began in 1996. These surveys were conducted in June in every year until 2004 when the surveys were moved to August. Surveys of the southern area of 2b, eastern 4a and area 2b began in 2001. The dates for these surveys have varied somewhat from mid-September to early October.

Lobsters are caught as a bycatch and are measured prior to being returned to the ocean. While the survey is not designed to assess lobster abundance, it is one of the few fishery-independent sources of information on lobster abundance. A description of the surveys can be found in Smith et al. (2003).

3. ABUNDANCE INDICATORS – LEGAL SIZES

3.1. Landings

3.1.1. Issues and Uncertainty:

Landing levels are a function of abundance, level of fishing effort (trap hauls, Soak Over Days (SOD), timing of effort and fishing strategy), catchability (environmental, gear efficiency, density, and migrations) and the distribution of animals and effort. Changes in any of these can affect landings. Thus landings are not an exact reflection of abundance. Caution must be observed as increasing effective effort or serial depletion of grounds could maintain landings at a high level for a period of time while absolute abundance is declining.

3.1.2. Historic Landings

Commercial lobster fishing began in the mid-1800s and annual lobster landings in the Gulf of Maine were first recorded in 1893. Landings peaked in 1898 at 12,995 metric tons (t) and were followed by a decline in landings, dropping to 1,600t in the early 1930s (Fig. 3.1.1). Concerns were raised as early as 1872, when a decline in the average size in the catch was first observed in nearshore catches. Over the next 50 years, numerous Government Commissions reviewed the decline and recommended changes in regulations in an attempt to stop further declines. The landings remained low (1600-3000t) during the 1930s and early 1940s. Landings rose following WW II, varying between 2200 and 4500t (averaging 3334t) until the 1980s. Landings increased throughout the 1980s as part of a western Atlantic wide pattern that saw landings increase over the entire lobster's range. LFA 34 landings peaked at 11,000t during the 1990-91 season (Table 3.1.1).

Landings in LFA 34 were down in 1991-92 and 1992-93 at 8876 and 8916t respectively. Landings remained between 9692 and 11886t from 1993-94 to 1998-99, then rose to 13,514t in 1999-2000 and 16503t in 2000-01 and 19,284t in 2001-02. For 2002-03 and 2003-04 landings have been close to 19,000t. Landings for 2004-05 are still preliminary (though believed close to complete) at 17007t.

Recent landings have been well above historic means (Fig. 3.1.2). LFA 34 landings presently account for close to 40% of Canada's lobster landings and over 20% of the total landings of *Homarus americanus* in the western Atlantic. (Fig. 3.1.3)

Time period	**Years**	**Mean**	**Mean 2001-02 to 2003-04**	**Ratio Recent years to long term mean**
10 year mean	1994-95 to 2003-04	14,273t	19,080t	1.3
25 year mean	1979-80 to 2003-04	9,927t	19,080t	1.9
25 year mean	1954-55 to 1978-79	3,224t	19,080t	5.9
50 year mean	1954-55 to 2003-04	6,576t	19,080t	2.9

Other LFAs and regions followed a similar trend in the early part of the century with major declines during the late 1890s to mid 1920s followed by fluctuations through to the 1970s (Fig. 3.1.4, 3.1.5, 3.1.6, 3.1.7). The increase in landings observed in LFA 34 during the 1980s was part of a wide scale increase observed over most of the range of lobsters in the western Atlantic. The overall trends were for increased landings during the late 1980s peaking in most areas in the 1990-91 period. Many areas have since declined including parts the Southern Gulf of St Lawrence fishery, Quebec, Newfoundland, Atlantic coast of Nova Scotia and Southern New England.

In the Gulf of Maine landings have remained high and continue to increase. Landings in Maine and the Bay of Fundy increased rapidly during the 1990s corresponding with similar increases observed in LFA 34.

3.1.3. *Statistical Districts Landings*

On a sub-LFA scale, landings can be examined by Statistical Districts (SD) (Table 3.1.2). These landings are based on data from port of landing or home port of fishermen. They do not provide information on where the lobsters are caught but can provide information of differing trends in landings within the LFA for the time period prior to the introduction of the grid logbook system (LFA 34 log book) for reporting landings in 1998-99.

Landings by Statistical District reflect the strong landings during the 1980s across the entire LFA with the largest absolute increases in SD 32-33 and the combined 36-38. (Fig. 3.1.8). On a relative scale comparing landings to their 1981-82 levels, SD 33 and combined 36-38 landings increased 6 times up to 2000-2001 but since 2001-02 have levelled off or declined slightly.

Indicators Table Summary- Landings

Indicator	
	LFA 34
Historical Landings – All of LFA 34 (1890-present)	
Last 3 seasons vs. 10 year mean 1994-95 /2003-04	+
Last 3 seasons vs. 25 year mean 1979-80 /2003-04	+
Last 3 seasons vs. 50 year mean 1954-55 /2003-04	+
Last 3 seasons vs. 50 year mean 1954-55 / 1978-79	+
Historical landings – Stat Districts (1981-present)	
Last 5 seasons vs. 10 year mean	+
Last 5 seasons vs. 20 year mean	+

Summary

Landings in LFA 34 as a whole continue to be above long-term means but peaked in the 2001-02 season.

3.1.4. *Landings by Grid Areas*

Landings based on the Grid Groups for fishing seasons 1998-99 to 2004-05 (Table 3.1.3) are presented by fishing period (fall, winter, spring) (Fig. 3.1.9 a) and by Grid Groups (Fig. 3.1.9b).

Landings are highest in the fall and lowest in the winter time period. Winter and spring landings have remained relatively constant over the time period. Fall landings increased between 1998-99 and 2001-02, then have declined but are still above the 1998-2000 period.

The individual Grid Groups (Fig. 3.1.9b) show different patterns.

- Grid Group1 (Yarmouth / St. Mary's Bay and 2b (Cape Sable Island) has been relatively constant.
- Grid Group 4a (German Bank) increased between 1998-1999 to 2001-02 and has remained relatively constant since.
- Grid Group 2a (Lobster Bay) peaked in 2001-02 but has declined over the last 3 seasons and is below landings of the 1998-2000 period.

- Grid Groups 3, 4b, 5, 6 and 7 increased between 1998-99 and 2003-04. Grid Groups 3 and 7 remained high in 2004-05 but Grid Groups 4b, 5 and 6 declined in 2004-05.

Grid Group landings by time period (fall, winter, spring) are presented in Fig. 3.1.10.

The mid and offshore areas (Grid Groups 3,4,5,6) have shown increases over the 1998-2004 time period with some showing decline in the 2004-05 season, but some caution is needed as the landings for that period may be incomplete. In contrast individual nearshore Grid Groups (1, 2a, 2b) have either remained relatively constant or in the case of Lobster Bay (4a) has declined.

As a proportion of the overall catch (Fig. 3.1.11; Table 3.1.4) the nearshore area has declined from 77% in 1998-99 to a low of 65% in 2003-04 with the midshore/offshore areas increasing by a factor of 3 over the same period.

Indicators Table Summary- Landings by Grids

Criteria: + if three of the last 5 years are > mean of 1998-99, 1999-2000
-- if three of the last 5 years are < mean of 1998-99, 1999-2000

Landings	1	2a	2b	3	4a	4b	5	6	7	LFA 34
Fall	+	--	+	+	+	+	+	+	+	+
Winter	--	--	+	+	+	+	+	+	+	+
Spring	--	+	+	+	+	+	+	+	+	+
Total Season	+	--	+	+	+	+	+	+	+	+
Proportion of landings	--	--	o	+	+	+	+	+	+	

Summary

Landings in sub-areas of LFA 34 (Grid Groups) generally followed the pattern of the LFA as a whole. A notable exception was a traditional nearshore ground (Grid Group 2a, Lobster Bay) which has declined 20% from the mean of the reference period (1998-99 to 1999-00).

3.1.5. Discussion

Landings increased from 13,514t in 1999-2000 to 19,000t in 2002-2003. Landings were already well above recent and long-term means and at record highs. Over this same time period landings declined in the traditional nearshore areas while increasing in the deeper water areas further from shore. The proportion of the catch from these areas increased from 11% to as high as 33% of the total catch.

Based on fishermen interviews (Duggan and Pezzack 1995), prior to the mid 1970s lobster fishing grounds were mainly limited to depths less than 30 fathoms. Inshore vessels began exploring further from shore and by the mid 1970s were fishing Browns Bank and German Bank (Grid Group 4a). This fishery continued to expand with some fishermen fishing the midshore all season and others fishing it for only part of the season, and moving nearshore when catch rates are higher there. The midshore fishing effort expanded during the 1980s and by 1994 represented approximately 10% of the LFA 34 landings (based on interviews).

The recent increase in landings in the midshore and deeper offshore areas in LFA 34 has occurred while the traditional nearshore areas have declined. In recent years there has been a problem of a higher proportion of soft and weak lobsters at the beginning of the fishing season. The higher proportion of the catch coming from deeper water areas may be a contributing factor to this problem.

3.2. Catch Rate From LFA 34 Log Books (1998-2004)

Catch rate (CPUE) calculated directly from the logbook data for the four time periods of the season (First 2 weeks, December, Winter, Spring) and expressed in pounds per trap haul are presented in Figure 3.2.1 and Table 3.2.1. Catch rates are not corrected for soak time. Soak times are generally shortest during the first two weeks of the season and longest during the winter months. Soak times are also generally longer in the midshore and offshore areas of LFA 34.

In almost all areas and time periods CPUE increased up to 2004-05 when in all areas CPUE was down.

Indicator Table Summary – catch rate (LFA 34 log books - raw)

Catch rate (LFA 34 log books, raw)	1	2a	2b	3	4a	4b	5	6	7	LFA 34
Fall	+	+	+	+	+	+	+	+	+	
Winter	+	+	+	--	+	+	+	+	+	
Spring	o	o	+	--	+	+	o	o	+	

3.3. Catch Rate From LFA 34 Log Books (1998-2004) – Model

3.3.1. Introduction

Annual mean commercial catch rates from a fishery are often used as indicators of population abundance with changes in the annual values expected to reflect similar changes in the population being fished (Quinn and Deriso 1999). However, catch rates may also reflect differences due to other factors such as time period and area being fished that are independent of population size. For this reason, statistical models are fit to these data to account for any extra variation that is independent of population change so that any changes believed to be related to population change can be detected. Here log-linear models are applied to catch and effort data from edited versions of the LFA 34 log books.

3.3.2. Methods

Data

We began with the edited data set of LFA 34 log books (data set 1, total number of records or days fished, reporting grid = 406,571). These data are plotted in Figure 3.3.1. We first created subsets of the data for each fishing period (fall, winter, spring) and Grid Group. For each model run we removed records where the catch rate was < 50lb/375 traps. This removed unrealistic low values and zeros. We also removed records associated with (i) licenses that had < 5 records for any given fishing period/Grid Group combination and (ii) licenses that had more than 35 records (fall) or 60 records (winter and spring) (days fished) for any given fishing period/Grid Group combination. The latter restriction was out of concern that some of these records were in error (duplicates). The final number of records used in the catch rate models is shown in Table 3.3.1.

Model

We modelled the effects of ancillary variables on catch rate in one of two ways. We declared License (fishermen effect) to be a random effect because we expect there to be consistent differences in catch rate among fishermen. These differences are expected to influence the initial catch in the season and the rate of decline of catch rate over the season. Here we are interested in the catch rate by the average fisherman over time. Differences between years are modelled as fixed effects because we expect them to affect all fishermen equally, once we have taken into account differences among fishermen as above. The full model is written as follows.

$$\mathrm{Log(CPUE)}_{ijk} \sim (B_o - b_{0k}) + (B_1 - b_{1k})\ \mathrm{seasonday}_i + \mathrm{Year}_j + \varepsilon_{ijk}$$

Where

B_0 is fixed effect (intercept)

b_{0_k} is a random license effect distributed as $N(0,\sigma^2_{bo})$

B_1 is fixed effect (seasonday)

b_{1_k} is a random license effect on seasonday distributed as $N(0,\sigma^2_{b1})$

Model exploration

The data in Grid Group 2a (Fig. 2.3) for the fall period were used to explore the model. A box and whisker plot indicates that when the data are grouped by week there are some differences due to week (Fig. 3.3.2) but plots of the data against season day (Fig. 3.3.3) indicate a stronger relationship. This was the basis for the decision to use season day as a covariate rather than grouping the data by week. There appears to be a possibility of a curvilinear relationship between log(CPUE) and seasonday (Fig. 3.3.3), but comparison of a linear fit to a loess fit within each year (Fig. 3.3.4), indicates the curvilinear trend is not strong.

The linear model fit to the data in each of the panels in the above figure was: log(CPUE)~1+seasonday. If we fit this model to each of the licence numbers within years we get the patterns shown in Figure 3.3.5. There are definitely some outliers or non-conformists here but the majority of licence holders experience a very similar pattern with time. Some of the unusual patterns are because some license holders had records for only a few days. This was partly the basis for eliminating records associated with licenses with fewer than 5 days recorded.

Estimates for the full model with random effects are presented in Table 3.3.2a. Test results in Table 3.3.2b indicate that accounting for the random effects increases the precision of the model while tests of the fixed effects in the model indicate that seasonday and year are significant. The residual plots by year (Fig. 3.3.6) indicate a slightly increased variation in recent years, and the residual plots for the random effect (licence – Fig. 3.3.7) show some outliers. Overall the residuals indicate no major problems with the model as fit.

Confidence intervals for the CPUE index are provided for years in Figure 3.3.8 and 3.3.9. The only difference between these two figures is that in the 3.3.9 the model is fit without the global intercept (B_0) in order to get an absolute intercept and confidence intervals for each year (Table 3.3.3). Note that for winter seasonday2 was 1 for Jan. 1 and for spring seasonday2 was 1 for Apr.1. In this way the year index for each period was indexed to the start of the period, as was the case for fall.

3.3.3. Results and Discussion

Confidence intervals for the CPUE index are provided for years within each Grid Group in the fall period in Figure 3.3.10, for the winter period in Figure 3.3.11, and for the spring period in Figure 3.3.12.

In general, the CPUE index period rose sharply during the fall from 1998-99 in virtually all Grid Groups, peaking in 2003-04 or 2002-03 in 7 of 9 Grid Groups. For the winter period, trends across Grid Groups were not as strong, but again most Grid Groups showed peaks in the CPUE index in 2003-04 or 2002-03. The spring period showed the most mixed trends, with four Grid Groups having a peak CPUE index in 2001-02 and two Grid Groups with their highest CPUE index in 1998-99.

Indicator Table Summary – catch rate (LFA 34 log books - model)

The trend in the CPUE index since 1999-2000 is summarized in the following table. A positive (+) indicates the CPUE index in the last 5 years was usually above that of the mean CPUE of 1998-1999 and 1999-2000. A neutral (**o**) indicates no trend. The criteria for a positive was if the confidence intervals for at least 3 of the last 5 years were non-overlapping (and above) those of the 1998-1999 and 1999-2000 seasons. For the comparison we "averaged" the confidence limits of the 1998-1999 and 1999-2000 seasons.

Catch rate (LFA 34 log books - *model)*	**1**	**2a**	**2b**	**3**	**4a**	**4b**	**5**	**6**	**7**	**LFA 34**
Fall	+	+	+	+	+	+	+	+	+	+
Winter	o	o	+	o	+	+	o	o	+	o
Spring	o	o	+	o	o	+	o	o	o	o

Summary

- A catch rate index for commercial sized lobsters was developed from a log-linear model of catch rate from LFA 34 log books and applied to Grid Groups for different fishing periods.
- The catch rate index indicates that catch rate in fall (season start to Dec. 31st) throughout LFA 34 was generally higher in the last 5 years compared to 1998-99 and 1999-00.
- The annual trends in catch rate index for winter (Dec. 31st-Mar. 31st) and spring (Apr. 1st to season end) periods were more mixed but in no Grid Group and period was the catch rate index negative relative to 1998-99 and 1999-00.

3.4. Catch Rate From FSRS Traps

3.4.1. Methods

As in the catch rate analysis of the LFA 34 log books, we used a log-linear model to analyze the data from FSRS traps. Some modifications to the approach were called for because of differences in the structure of the FSRS data. In the FSRS project the number per individual size group was recorded on a daily basis from 2 traps per fishermen. With the many zeros and low numbers present it was difficult to model the data of individuals against season day as was done for the LFA 34 log books. Instead we aggregated the data by week for individual fishermen.

The data for all FSRS trap hauls for the period in LFA 34 are shown in Figure 3.4.1. Within each year a distinctive "U" shaped pattern is evident, showing the decline in catch rate from the season start until spring when catch rates increase again. The "U" is more symmetrical than in the commercial CPUE data (Fig. 3.3.1) because the FSRS catches are comprised mainly of pre-recruit lobsters that are not removed by the fishery.

Since most of the FSRS traps were set within Grid Groups 2a and 2b we restrict our analysis to these and treat them as one group, "2ab". We are concerned here with legal sizes; in a later section (5.1) we deal with some of the other size groups recorded in the FSRS recruitment traps.

Catch rate of legal sizes per week per fisherman in Grid Group 2ab is plotted against week (summed over all traps) in Figure 3.4.2.

The following model was used:

Log(no. per trap haul)~1+ week + fisherman ("VesselCode") + year ("Season")

Week was a covariate and fisherman and season were factors. The term 1 represents the global intercept. Zeros were removed prior to the fitting the model.

3.4.2. Results and Discussion

Fall Period

The model fit for the fall period is reasonable based on the residual plots (Fig. 3.4.3 - residuals versus fitted values, Quantile/Quantile (Q/Q) plot of standardized residuals, scale-location plot and Cook's distance plot). There are some outliers but they do not appear to have had much influence.

The analysis of variance (ANOVA) table with the global intercept fitted indicated that week, fisherman and season were all significant (Table 3.4.1). Estimates of the model coefficients for Season indicate that legal sized animal catch rates in fall were significantly higher than 1999 for 3 of 5 of the seasons (Table 3.4.1).

Confidence intervals for the year index without the global intercept are shown in Figure 3.4.4. Note that this index is standardized to week 1 and a particular vessel code. Other vessel codes would show the same trend. The intervals show a broad peak from 2001-

2003, followed by a decline in 2004. This is similar to what was seen in the analysis of commercial CPUE (Fig. 3.3.10).

Spring period

The spring period was defined as beginning in week 19 of the season, which falls either in late March or early April depending on the season start date. For purposes of the analysis, we defined covariate "week2" such that week 19 was equal to 1. In this way the CPUE index was referenced to the start of the spring period rather than the start of the fishing season (late November). The data are plotted in Figure 3.4.5.

The ANOVA indicated that all main effects were significant (Table 3.4.2). Estimates of the model coefficients for Season indicate that legal catch rates in fall were significantly higher than in 1999 for all of the seasons (Table 3.4.2). Confidence intervals for the year index for CPUE (global intercept removed) are shown in Figure 3.4.6, standardized to week 1 and a particular vessel code. They indicate that 1999 was anomalous and that the last 4 years show no particular trend. The commercial CPUE in 1999 was also lower than subsequent years in Grid Groups 2a and 2b (Fig. 3.3.12).

Indicators Table Summary Legal Sizes- Catch Rate (FSRS Traps, Model)

The trend in the CPUE index since 1999-2000 is summarized in the following table. A positive (+) indicates the CPUE index in the last 5 years was usually above that of the mean of 1998-99 and 1999-00. For the FSRS data begins only in 1999-00.

	1	2ab	3	4a	4b	5	6	7	LFA 34
Fall		+							
Winter									
Spring		+							

Summary

- A catch rate index for commercial sized lobsters in FSRS traps was developed from a log-linear model applied to Grid Groups 2ab for Fall and Spring.
- The model indicated that compared to 1999-00, CPUE of legal sized lobsters was usually higher, but shows no upward trend.
- The FSRS CPUE index gave some of the same signals as the commercial CPUE index.

3.5. Scallop Survey

3.5.1. Methods

The scallop survey database was accessed to obtain numbers and sizes of lobsters caught as a bycatch during scallop surveys.

3.5.2. Results and Discussion

Locations of scallop tows for two periods are shown in Figure 3.5.1 a,b. Since 2000, the survey has been extended into Grid Groups 2a and 2b. Figure 3.5.2 shows the size frequency of lobsters captured during all the scallop surveys. Most lobsters captured are below the minimum legal size (MLS), but there are a few large lobsters caught. The mean number of lobsters per tow for sublegal and legal sized lobsters by Grid Groups shows some trends with time (Fig. 3.5.3 and 3.5.4). Grid Groups 1 and 2a show elevated lobster catch rates beginning in 1998 or 1999; Grid Group 4a shows an increase in 2000. Some of these increases are due to sampling closer to shore in recent years. Grid Group 2b (Fig. 3.5.4) has been sampled for too few years to assess a trend while few lobsters are caught in the other Grid Groups.

Considering the period 2001-2005 relative to 1999-00 we see some negatives and positives. In Grid Group 1 the catch rate of legal lobsters was lower in all 5 years from 2001 and 2005, while the catch rate of sublegals was lower in 4 of 5 years. In Grid Group 2a the catch rate of legal lobsters from 2001-2005 was generally higher than 1999-00, while for sublegals it was lower. In Grid Group 4a, the catch rate of legal sizes and sublegal sizes from 2001-2005 was generally above that of 1999-00.

Indicator Table Summary (Legal Sizes)

	1	2a	2b	3	4a	4b	5	6	7	LFA 34
Catch rate in scallop survey	--	+			+					

4. FISHING PRESSURE INDICATORS

4.1. Commercial Fishing Effort

4.1.1. Number of Grids and Days Fished

Methods

The number of number grids and days fished was determined using the LFA 34 log book data subset. A count of unique grids fished by each fisherman was calculated and an average number of grids fished were plotted for each season. As well, an average number of days fished was plotted for each season (Fig. 4.1.1, 4.1.2). The methodology was applied to LFA 34 as a whole.

Results and Discussion

Considering the period 1998-99 to 1999-00 relative to 2000-01 to 2004-05, the average number of grids fished per fisherman has increased in all 5 years from 2001 while the average number of days fished is lower in 3 of 5 years.

In the indicator summary table a decrease in days fished is given as a "**+**" as it represents a potential decrease in fishing effort however the reason for the increases is not clear from the data. There are a number of potential reasons for a decrease in days fished: weather, low catch rates resulting in longer soak days and fewer trips, more effort in the mid and offshore where soak days are generally longer, or high catches and economic returns reducing the need to fish as hard.

Similarly in the indicator summary table an increase in grids fished is given as a "**--**" as it represents potential increase in fishing effort however the reason for the increases is not clear from the data. There are a number of potential reasons for fishing more grids:

increased lobster movement, lower catch rates, changes in fishing grounds which span more grids though actual area fished is the same.

4.1.2. Number of Trap Hauls From LFA 34 Log Book Data

Methods

Increases in landings can be related to changes in abundance, or changes in effort or catch rate. Prior to the introduction of LFA 34 log books in 1998-99 there was no measure of effort other than the number of licenses. With the LFA 34 log books it is now possible to determine changes in the number of trap hauls, days fished and changes in areas fished. The data is based on the records with complete data (landings, trap hauls and grid number), and as such it does not represent the total effort.

Information on the effective effort was not captured in the LFA 34 log books. The effective effort can change with changes in trap design, bait, boat size and fishing strategies (location of trap, soak time, distance between traps on a trawl etc.). Fishermen are continually experimenting with designs and bait to optimize their catch and over time the effectiveness of traps will increase. Our inability to track these changes is an important deficiency in our data.

Results and Discussion

Total trap hauls per fishing season by Grid Groups are given in Figure 4.1.3a (Table 4.1) and as proportion of total traps hauled in Figure 4.1.3b. Trap hauls by fishing period are presented in Figure 4.1.4.

Considering the period 1998-99 to 1999-00 relative to 2000-01 to 2004-05, the average number of trap hauls as number and proportion of the total traps hauled remained relatively stable in Grid Group 1 and 2b but steadily declined in Grid Group 2a (Lobster Bay). Trap hauls increased in all of the midshore and offshore areas with the largest increase in Grid Group 4a (German Bank).

In the indicator summary table a decline in effort is given a "+" as it is reducing effort however the reason for the decrease in effort in what has been traditionally the dominant area for effort and landings, is unknown. A shift of effort from this traditional nearshore area to areas further from shore could represent a concern if it reflects a change in abundance of lobsters in this important nearshore habitat.

Indicator Table Summary - Fishing pressure – traps hauled and grids fished)

	1	2a	2b	3	4a	4b	5	6	7	LFA 34
Trap Hauls Number	+	+	--	--	--	--	--	--	--	--
Trap Hauls Proportion of Total	o	+	--	--	--	--	--	--	--	--
Number of Grid Fished										--
Number of Days Fished										+

4.2. Size Composition (% in Molt Group 1)

A simple indicator of changes in exploitation rates are changes in the size frequency of the catch. Though not as precise as other methods it requires less data.

A fishery removes animals in the legal size range. At moderate or high exploitation rates the slower growing larger sizes are reduced and the population size composition is truncated. While an unfished lobster population will contain lobsters larger than 200mm CL, and up to 10 molt groups with a high percentage in the mature age groups (>97mm CL), in the heavily exploited nearshore populations the larger sizes are lacking or reduced to very small numbers and catches are dominated by the first molt group, animals that are newly recruited to the legal sizes. These are referred to as recruitment based fisheries.

In measuring changes in the proportion of the catch in the first molt group, one may be able to detect trends in exploitation rates. A weakness of the method is that it assumes constant recruitment. During a period of high recruitment the proportion of the catch in the first molt group will increase. A second weakness is that in fisheries with an already high percentage of the catch in the first molt group changes may be difficult to detect.

4.2.1. Method

Catch size frequencies for each fishing season were obtained for each Grid Group and the proportion of animals in each molt group was calculated. Molt groups for 1998-99 to 1999-00 were 81-94, 94-109, 110+mm CL. After the size increase in 2000 the molt groups were adjusted to 82-95, 96-110, 111+mm CL.

The size frequency data from at sea samples were combined to give a size frequency for each of the Grid Groups for each fishing period and year. For Grid Groups 5 and 6 there were insufficient sea samples to give a size frequency by fishing period or season. Review of the data available showed that in these areas there were no apparent changes with fishing period or over the time period of the analysis (1998-2005) so years and seasons were combined. For this reason, year to year comparisons in the percentage in the various molt groups could not be done. For other Grid Groups, gaps in the data were filled using the size frequency from the previous or following years.

The size frequencies were expanded using landings reported in the LFA 34 log books for the Grid Group and fishing period (first 2 weeks, December, winter (Jan-March) and spring (April-May)).

Examples of the size frequencies used are shown in Figure 4.2.1. with numbers landed at size for 1998-99 and 2003-04 and 2003-04 with the y axis expanded to show the shape of the frequency in those Grid Groups with lower catches.

4.2.2. Results and Discussion

The size frequencies of the catch vary with areas fished (Fig. 4.2.1; 4.2.2, Table 4.2.1; 4.2.2, 4.2.3, 4.2.4 a,b,c). The nearshore Grid Groups (1, 2a and 7) exhibit typical size frequencies for recruitment-based fisheries dominated by the first molt group (>80%) and few lobsters > 100mm CL. The nearshore Grid Group 2b has a higher percentage of animals in the second molt group than the other nearshore Grid Groups. This size difference is the reason for dividing Grid Group 2 into two sub areas.

In the midshore Grid Groups (3, 4a, 4b) molt group 1 ranges from 67% in Grid Group 4b to 70% in Grid Group 3 and 80% in Grid Group 4a. In Grid Group 4a the proportions in each of the molt groups are similar to those of the nearshore areas, though the proportions near the legal size is less.

The more offshore areas have size frequencies dominated by the second and third molt groups with a wide size range. This is similar to what is observed in the adjacent offshore (LFA 41) areas.

Establishing an indicator for the changes in percentages of animals in the first molt group over time is difficult as there are potentially different processes in the different areas. In a nearshore area with already high percentages of animals in the first molt group, a decline in the percentage could suggest reduced recruitment, especially when it also occurs with a drop in landings, and this would be considered negative. Another possible explanation could be a targeting of larger sizes by the fleet, which could also have negative consequences as these are the reproductive sizes.

In the midshore and offshore areas one of the concerns is a fishing-down of the population, shifting more and more of the landings to the newly recruited animals and reducing the reproductive output. Increases in the percentage in the first molt group could be due to a fishing-out of larger sizes and a truncation of the population size frequency. It could also be due to increased recruitment.

Because of the differing potential causes of changes in the proportion in the different size groups, the table below gives the direction of the change rather than whether it is positive or negative for the fishery.

Indicator Table Summary - Fishing pressure – Molt group percentages

	1	2a	2b	3	4a	4b	5	6	7	LFA 34
% in 1st molt group	--	--	o	+	+	+	+			--
% in 2nd molt group	+	+	+	--	--	--	+			+
% in 3rd molt group	+	+	--	--	--	--	-			+
% females>size maturity	+	+	+	--	--	o	o			+

If there has been a drop in recruitment or a fishing-down of the larger sizes in the midshore areas it would be a concern and efforts should be made to assess this situation and determine if this is what is occurring.

4.3. Length Composition Analysis (LCA)

4.3.1. Method

LCA was developed by Jones (Jones 1974; Jones 1981) based on Pope's (Pope 1972) cohort analysis which assumes that abundance at the end of year i can be estimated by the initial abundance(N_i), a half year of natural mortality (M), a mid year catch (C) and natural mortality for the remainder of the year.

$$\left(N_i e^{-0.5M} - C\right) e^{-0.5M} = N_{i+1}$$

Instantaneous fishing mortality (F) can be estimated from a sequence of cohort abundance over several ages. The equation is arranged from oldest to youngest ages.

$$C_i e^{0.5M} + N_{i+1} e^{M} = N_i$$

Many species cannot be aged so an annual model cannot be applied. Jones (1974) modified the equation to include variable time intervals (Δt)

$$C_i e^{0.5M\Delta t} + N_{i+\Delta t} e^{M\Delta t} = N_i$$

Size distribution of landings was used to estimate the catch for the sequence of time intervals and von Bertalanffy growth parameters were applied to estimate the Δt. The method was further modified by Cadrin and Estrella to include the time of the catch (Tc). This allows it to be varied from 0.5.

$$C_i e^{T_c M \Delta t} + N_{i+\Delta t} e^{M \Delta t} = N_i$$

They also incorporated a quadratic growth curve derived from molt increment and molt probability at-size to calculate Δt at-size.

The details of the method, sensitivity analysis and sample outputs can be found in the Northeast Fisheries Center Reference Document 96-15.

In the present assessments the method of deriving Δt was modified. Rather than calculating Δt at-size by fitting a quadratic growth curve derived from molt increment and molt probability at-size, Δt was obtained from the output of the Idoine-Rago Egg and Yield per Recruit program. This program simulates the progression of a cohort through its lifetime. When the program is run with F=0.0 an output file produces a table of mean number of years at-size which can be used as the Δt's.

4.3.2. Assumptions and Limitations

Since this method is not following a single cohort over time, but instead assumes that the size frequency represents the abundance of a cohort over time, the method assumes constant recruitment. In practice, however, this is not the case and estimates are generally based on the mean of several years.

In conditions where the recruitment is dramatically changing year to year, as has been the case in the Bay of Fundy where recruitment was high in the late 1990s, such values should be used with caution. Similarly where fishing patterns change resulting in changes in the mix of sizes in the catch, estimates of exploitation rate will be effected. For example an increase in fishing effort in deeper water areas with a large mean size could result in lower estimate of exploitation rate.

4.3.3. Data Input

Terminal F

Terminal F is the value of F applied to the last size group. Cadrin and Estrella (1996) showed that the resulting weighted F is not sensitive to this value. Values between 0.1 and 3.0 were applied with no significant effect.

M (Natural Mortality)

M is set at 0.10

Tc (Time of catch)

The time of catch is the period in the year when the catch is taken. The year begins in August following the molt and Tc is set as the month in which cumulative landings reach 50% of the total. For LFA 34 this occurs in December.

Catch Numbers (Size frequency)

In this report only females were run. Sizes were grouped into 5mm or 10mm CL groups. The 10mm groupings are used at larger sizes when numbers in any size group becomes small or are absent. The smaller groupings are most critical at the smaller sizes where Delta t has the largest changes.

ΔT

Δt are calculated from the output of the E/R program. The mean time at size for each 1mm size group is obtained from the E/R model output.

4.3.4. Results and Discussion

Exploitation rates were estimated for LFA 34 as a whole, and for Grid Group 2a alone (Fig. 4.3.1, Table 4.3.1) The range of values for exploitation rate for females was 0.66-.71 (mean 0.68) for LFA 34 and 0.72 – 0.80 (mean 0.75) for Grid Group 2a.

Since this method is not following a single cohort over time, but instead assumes that the size frequency represents the abundance of a cohort over time, the method assumes constant recruitment. In practice, however, this is not the case and estimates are generally based on the mean of several years and thus caution is needed in interpreting any year to year changes.

The estimates indicate a high but relatively stable exploitation rate in LFA 34 and in the nearshore Grid Group 2a.

Indicator Table Summary - Fishing pressure – Exploitation rate from LCA

	1	2a	2b	3	4a	4b	5	6	7	LFA 34
Level of exploitation rate		--								--
Trend in exploitation rate		o								o

4.4. Change-in-ratio

4.4.1. Exploitation Rate Indicators: Methods

We define exploitation rate as (catch / population numbers) x 100. Management measures initiated during the 4-year plan were designed to reduce exploitation rate and increase E/R. We use a change-in-ratio method (Claytor and Allard 2003) to estimate exploitation rate by length-class for designated sub-areas.

Two exploitation rates were examined. The first, called the strict exploitation rate is defined as the percentage or proportion of the exploitable population caught during a fishing season. However, regulations that increase the minimum legal size can result in a smaller exploitable population and therefore increase the exploitation rate, even if catch is constant. As a consequence, a second exploitation rate was examined, called the extended exploitation rate. The extended exploitation rate is defined as the proportion or percentage of the number in the exploited population plus the number in some non-exploited portion of the population. The extended exploitation rate allows a consistent base population to be compared between years that are independent of changes in the legal size.

Exploitation rate estimates were obtained from the FSRS recruitment trap data using the method described by Claytor and Allard (2003). This method uses the change-in-ratio between a reference or unexploited class and an exploited class over the fishing season to estimate exploitation rate.

The assumptions of the analysis are that (1) the population is closed, (2) that the ratio of catchability between the classes is constant throughout the season for all traps, (3) that the ratio of catchability by the monitoring traps and by the commercial traps is constant over the season for all classes and (4) that the ratio of the fleet effort to the monitoring trap effort is either constant over the season or can be estimated up to a constant factor.

For 1999-00, the sub-legal size group 75 – 80mm was used as the reference group for the 81-90mm exploited size group. For all subsequent years, 2000-01 and on, 81 – 82.5mm was used as the reference group for the 82.5 – 90mm exploited size group. Thus for 1999-00 the strict exploitation rate applies to 81-90mm animals, and for subsequent years, the strict exploitation rate applies to 82.5-90mm. For 2000-01 and subsequent seasons, the extended rate applies to the 81-90mm size group.

The methodology was applied to three areas: Area 1 (Grid Group 1), Area 2 (Grid Groups 2a and 2b combined), and Area 3 (All other Grid Groups combined). Parameters were considered significant if the confidence limits of the parameters estimated (A and B parameters given in equation 2 of Claytor and Allard) did not include 0. Sample size has an important effect on the reliability of the result. The best estimates are obtained when reference and legal classes both exceed about 200 animals. Estimates derived from sample sizes smaller than this, should be interpreted with caution, even if the parameters are significant. Cases with smaller sample sizes that may affect reliability occur in the larger size classes (Claytor 2004).

4.4.2. Exploitation Rate Indicators: Results

Significant and reliable estimates were obtained only for Area 2 (Grid Groups 2a and 2b combined) (Fig. 4.4.1). Sample sizes in the other areas were too low in most years to provide reliable estimates even when parameters were significant (Table 4.4.1) and results are reported only for Area 2. Estimates from this area were significant for all sizes and years with three exceptions: Males > 100mm, females, 91-100mm, and females >100mm from 2003-04 (Fig. 4.4.1). Extended exploitation rates are lower than the strict exploitation rate for 1999-00, however, the differences are not significant. Extended exploitation rates are significantly lower than strict exploitation rates in only one year. Because these differences are not significant no change in exploitation rate is noted in the summary table. Exploitation rate estimates of length-classes 91-100mm and >100mm, where comparisons are possible, indicate no change in exploitation rate on these sizes as well (Fig. 4.4.1).

Example plots of raw data, observed versus predicted values, and residuals indicate that no pathologies occur in the analysis (Fig. 4.4.2 a-h). Distribution maps of sampling locations show an increase in number of sites and spatial coverage over time (Fig. 4.4.3 a,b,c).

4.4.3. Exploitation Rate Indicators: Discussion

These results indicate that increases in MLS were useful in reducing exploitation rate of affected length-classes, but have not been sufficient to detect significant differences given the sample sizes of reference and exploited populations in the FSRS data. These estimates are most reliable when reference and exploited length-classes are adjacent and narrow (Claytor and Allard 2003). Interpretations of changes in exploitation rate on lobster larger than 91mm should be interpreted with this caveat. However, that no change has occurred in the exploitation rate of larger sizes is expected because there have been no changes made to the management plan that would affect exploitation rate on these lobster.

This method has been successful in detecting significant differences in exploitation rates due to size increases in LFA 33 where sample sizes are larger and in LFA 27 where sample sizes and carapace length increases have been greater. Increased participation in the FSRS program and subsequently, sample size, has occurred in recent years. For this indicator to make a contribution to future LFA 34 assessments the increased participation observed in recent years must continue.

Indicator Table Summary - Fishing pressure – Exploitation rate from CIR

Exploitation rate - CIR	1	2ab	3	4a	4b	5	6	7	LFA 34
Extended (81-90, Males)		o							
Strict (MLS-90, Males)		o							
Strict (91-100, Males)		o							
Strict (>100, Males)		o							
Extended (75-90, Females)		+							
Strict (MLS-90, Females)		o							
Strict (91-100, Females)		o							
Strict (>100, Females)		o							

4.5. Depletion Model Estimates of Exploitation

A number of methods have been proposed to estimate population size and exploitation rate (e.g., Leslie and Davis 1939, DeLury 1947, Dupont 1983) by modelling the rate of decrease in commercial catch over time as a function of effort. These so-called depletion methods assume the population is closed with respect to death, birth, permanent immigration and emigration over the time period that the catch and effort data are collected. While these assumptions are unlikely to be true for most natural marine populations over an entire year, they may hold for short periods of time during the year. Assuming that catches are the only removals from the LFA 34 lobster fishery during the first month or so of the fishery, we have analyzed catch and effort data from the FSRS recruitment traps and the LFA 34 log book data in area 2a (Lobster Bay). Here we use a modified form of the depletion method developed by Gould and Pollock (1997). This method is preferred here because it allows for inclusion of effort and other covariates such as temperature in a generalized linear model format. The original development used maximum likelihood methods to estimate parameters, however, methods for estimating confidence intervals and screening different models were difficult to develop in this context. Here we use a Bayesian approach for estimation in which estimation of confidence intervals and model screening methods are easily and naturally developed.

4.5.1. Methods

Gould and Pollock (1997) model each event (e.g., day) where catch and effort data are collected as a Poisson distribution for the number of lobsters caught, n_i, where $i=1,\ldots,s$. The joint distribution of all of the lobster caught on the first day, the second day, etc., plus a term representing the lobsters not caught on any of the s days, written as $(N_0-\Sigma\, n_i)$, where N_0 is the total population size available at the beginning of the fishery, is a multinomial distribution with a very specific form for the probabilities associated with each of the events. The probabilities for each of the n_i are structured such that the probability of being captured at time i=1 is p_1, at time i=2 the probability of being captured is given as the probability of not being captured at time 1 times the probability of being caught at time 2 i.e., $(1-p_1)\times p_2$, and so on. The probability associated with the event of not being captured at all is simply 1 minus the sum of all of the probabilities of being captured at time 1, 2, up to time s. Gould and Pollock (1997) partition the full likelihood into two parts, one for the observed catches and the second for the total of the observed catches and the lobster not caught. For both the maximum likelihood and Bayesian methods, the general approach is to estimate the probabilities of being captured at each time period in the first likelihood function and then estimate N_0 from the second partition of the likelihood. Exploitation is simply estimated as $\Sigma\, n / N_0$.

Bayesian estimates were calculated using the Monte-Carlo Markov Chain (MCMC) approach in the public domain package WinBugs (Spiegelhalter et al. 2005). Each MCMC run was conducted on two chains of initial values with a burn-in of 5,000 replications and 20,000 replications for estimation and confidence intervals. A uniform prior was used for N_0 with lower bound corresponding to $\Sigma\, n_i$ and upper bound set to at least 150×10^6 lobsters.

Covariates such as effort or temperature are modeled as functions of the p_i as an exponential function or the canonical logit (log-odds) link function. That is,
$p_i = 1 - \exp(-k\times\text{effort}_i)$,

where k was assigned a Beta prior with parameters $a=b=1$ (equivalent to a uniform(0,1) distribution),

$\log(p_i/(1-p_i)) = \alpha + \beta_1\times\text{effort}_i$ and

$\log(p_i/(1-p_i)) = \alpha + \beta_1\times\text{effort}_i + \beta_2\times\text{temperature}_i$,

where α, β_1, and β_2 were assigned normal priors with mean 0 and variance 1×10^4.

All of the above models were compared using the Deviance Information Criteria (DIC, Spiegelhalter et al. 2002) which is analogous to the Akaike Information Criteria (AIC) used for non-Bayesian models.

4.5.2. Results

LFA 34 Log Book Data

Catch and effort data for legal size lobsters were summed for each day in the LFA 34 log book records over the period from the start of the fishery at the end of November to

December 31st for the years 1998 to 2004 (Fig. 4.5.1). Temperature data were not available from the commercial fishery and catch was modeled as a function of effort using either the exponential or the logit model. These models were fit to the data year by year.

Comparing the fits of the two kinds of models to these data using DIC (smaller is better, with differences being greater than 5 accepted as significant) suggests that except for the 2002-03 and 2004-05 season, the exponential model was preferred (Table 4.5.1 a).

The trends in exploitation from the two models are similar in the initial and final years but the logit model suggests that there was a greater decline in exploitation in 2000-01 to 2003-04 than the exponential model (Fig. 4.5.2). However, as noted above the exponential model tended to fit the data better than the logit model.

FSRS Data

Catch and effort data for legal size lobsters were summed for each day in the FSRS records over the period from the start of the fishery at the end of November to December 31st for the years 1999 to 2004 (Fig. 4.5.3).

Temperature data were available for these catch and effort data and were included here as daily averages. Changes in bottom water temperatures have been identified as potential modifiers of catchability of lobsters in traps (McLeese and Wilder 1958, Drinkwater et al. 2006). A comparison of catch rate (numbers per trap haul) from the FSRS data from the beginning of the fishing season to the end of December shows an apparent relationship with temperature (Fig. 4.5.4). While the strength of the relationship appears to vary over the six years presented, in some years (2002–2004) there appears to be a strong linear to curvilinear relationship. However, temperature and effort are also highly correlated for all years except 2000 making it difficult to disentangle the separate effects of effort and temperature on catch (Fig. 4.5.5).

The results of fitting the Gould and Pollock model to the FSRS data seem to favor the exponential model for most years except for 1999 and 2002 based on DIC (Table 4.5.1 b). However, the DIC measure presented here pertains only to the multinomial part of the model for the observed catches. The DIC for the second partition of the likelihood had a negative complexity component indicating that the model did not fit the total catch data very well. Despite this, the time series and confidence intervals for the exploitation estimates for the exponential and logit model were very similar (Fig. 4.5.6).

The logit model with temperature only, worked for the data from 1999 to 2001 and the estimates did not converge for 2002 to 2004. While only the data for 2000 resulted in an improved fit with temperature, exploitation estimates for the first three years actually increased with the addition of temperature into the model. Note that 2000 was the only year where temperature and effort were not correlated.

4.5.3. Discussion

The estimates from the LFA 34 log book data and the FSRS data for Grid Group 2a agree in general about the magnitude of exploitation but do not agree in the fine details about the trend. Exploitation estimates for fall period of the most recent complete season (2004-05) are in the range of 0.76 to 0.87 from all of the models and data sets.

The identification of the effects of temperature on catch was complicated by the strong correlation between temperature and effort. In the one case where there was no correlation (2000-01), the effect of temperature was significant and its inclusion in the model resulted in exploitation being estimated higher than with effort alone.

Indicator Table Summary - Fishing pressure – Exploitation rate from GPD

Exploitation rate - GPD	1	2a	2a	3	4a	4b	5	6	7	LFA 34
Exponential - LFA 34 log book		o								
Logit - LFA 34 log book		o								
Exponential - FSRS data		--								
Logit - FSRS data		o								

5. PRODUCTION INDICATORS (PRE-RECRUIT AND SPAWNER ABUNDANCE)

5.1. Pre-recruit Catch Rate From FSRS Logs

5.1.1. Methods

We use the same approach as that outlined in Section 3.4.

5.1.2. Results

FALL

< 61mm CL

The ANOVA table indicates no significant effects due to week or season. Thus there are no significant changes in CPUE of this size group relative to 1999-00 (Table 5.1.1). Given the large number of zero values that could not be included in the analysis (223 of 701 records) this analysis is not as reliable as others.

61mm to 70mm CL

The data are plotted in Fig. 5.1.1. The ANOVA table (Table 5.1.2) indicates a significant effect due to season and vesselcode, but not to week. Estimates of the model coefficients for Season indicate that catch rates for this size group in fall were significantly higher than 1999 for all of the seasons except 2004-05 (Table 5.1.2).

The confidence intervals from the model are shown in Figure 5.1.2. They indicate a peak in the 2001-02 and 2002-03 seasons.

71mm CL to MLS (minimum legal size)

The data are plotted in Figure 5.1.3. The ANOVA table (Table 5.1.3) indicates a significant effect due to week, season and vesselcode. Estimates of the model coefficients for Season indicate that catch rates for this size group in fall were significantly higher than 1999 for 3 of 5 seasons (Table 5.1.3).

The confidence intervals from the model are shown in Figure 5.1.4. They indicate 1999 and 2000 were similar, while 2001-2003 were higher. The mean for 2004-05 was lower and not significantly different from 1999.

SPRING

< 61mm CL

The data are plotted in Figure 5.1.5. The ANOVA table (Table 5.1.4) again indicates a significant effect for all main effects. Estimates of the model coefficients for Season indicate that catch rates for this size group in fall were significantly lower than 1999 for 2 of 5 seasons.

The confidence intervals from the model are shown in Figure 5.1.6. They indicate no consistent pattern.

61mm to 70mm CL

The data are plotted in Figure 5.1.7. The ANOVA table indicates all main effects are significant (Table 5.1.5). Season coefficients indicate two years were significantly lower than the first season.

There is a suggestion of a downward trend in the confidence intervals over the years but it is not significant (Fig. 5.1.8).

71mm CL to MLS (minimum legal size)

The data are plotted in Figure 5.1.9. All main effects were significant (Table 5.1.6). There is no consistent trend in the confidence intervals over the years (Fig. 5.1.10).

Indicator Table Summary – Pre-recruit catch rate (FSRS traps, model)

The trend in the CPUE index since 1999-00 is summarized in the following table. A positive (**+**) indicates the CPUE index in the last 5 years was usually above that of 1998-99 and 1999-00. A neutral (**o**) indicates no trend.

	1	2ab	3	4a	4b	5	6	7	LFA 34
Fall									
<61		o							
61-70		+							
71-MLS		+							
Spring									
<61		o							
61-70		o							
71-MLS		o							

Summary

- A catch rate index for pre-recruit lobsters in FSRS traps was developed from a log-linear model and applied to one nearshore Grid Group (2ab).
- The model indicates that relative to the 1999-00 season, fall catch rates in the last 5 years were generally higher for two pre-recruit size groups.
- Mean catch rates for these 2 pre-recruit sizes have trended downwards in the last 1-2 years and are now at levels similar to 1999-00. Whether the decline in immediate pre-recruits (71mm to MLS) in 2004-05 is the start of a longer trend is not known, but if the catch rate of 61-70mm CL is an indicator, it will continue.
- For the smallest size groups (< 61mm CL) the number caught was too low for useful estimates of catch rate.

5.2. Spawner Catch Rate from FSRS Logs

There were too few spawners captured in the FSRS traps to conduct a meaningful analysis (Fig. 5.2.1 and 5.2.2). In the fall period 645 of a total of 701 records were 0; in spring 1,226 of a total of 1,333 records were 0.

5.3. Catch Rate of Pre-recruits in At-sea Samples

5.3.1. Results and Discussion

The mean catch rate of pre recruits (70-79mm CL) from at sea samples (1988-2005) are presented in Figures 5.3.1 for Grid Groups 1, 2a, 2b, 7, 3, and 4b by fishing periods.

The mean catch rates are highly variable and patterns vary with the fishing period.

Grid Group 1 exhibits no strong trend in any of the fishing periods.

Grid Group 2a fall and winter exhibits higher catch rates in the last 5 years compared to those in the 1988-1998 period with an upward trend in recent years during the first 2 weeks of the season. This upward trend is not however seen in the December, winter or spring samples which show no trend since 1998.

Grid Group 2b shows no trend in recent years but the values are slightly higher than during the early 1990s.

Grid Groups 7 and 3 show no trends.

Grid Group 4a shows higher catch rates in the recent years compared to the mid 1990s but no strong trend in recent years.

Catch rates of pre-recruits is often presented as a tool for tracking recruitment and forecasting future landings. At the present level of sampling, catch rates are highly variable from fishing period to fishing period within the same season as well as from year to year. There are no indications of trends in recent years either up or down. In those Grid Groups with data from the late 1980s and early 1990s it appears that catch rates have increased since that time, but caution must be used as trap design and materials have changed and these may affect the catch rates.

At sea samples are snap shot pictures of the catch on a single day and location. Location and day within the season vary and may result in the lack of trends in the data. Analysis by individual grids might reduce the variation but the data set would be greatly reduced and there would be insufficient numbers and years for analysis. A future strategy may be to more intensely sample specific sites.

5.4. Catch Rate of Berried Females in At-sea Samples

5.4.1. Results and Discussion

The mean catch rate of berried females from at sea samples (1988-2005) are presented in Figures 5.4.1 for Grid Groups 1, 2a, 2b, 7, 3, and 4b by fishing periods.

Catch rates of berried females are extremely low in all areas and time periods. Values are highly variable and no trends are observed.

As an indicator it appears that berried female catch rates is of very limited value due to its low level and high variability.

Indicator Table Summary - Catch Rate of Pre-recruits and Berried Females

Catch rate from at-sea samples	1	2a	2b	3	4a	4b	5	6	7	LFA 34
70-79mm CL	o	o	o	o	o					
Berried females	o	o	o	o	o					

6. GENERAL DISCUSSION

The Indicators for abundance, fishing pressure and production are shown in Table 6.1. They provide a perspective on how different characteristics have changed since the last assessment in 2000.

6.1. Abundance

With the implementation of the LFA 34 log books, we have a powerful set of data which has become much more useful since the last assessment. We now have a better grasp of where fishing takes place and how it changes within and between seasons. The landings from these logs are useful as an abundance indicator to the extent that effort remains constant for the periods being compared. Effort changes may be related simply to more trap hauls, which can be accounted for by calculating catch per unit effort (CPUE). If effort changes in quality (changes in fishing strategies, better traps, bait, and navigational equipment) then this will not be captured by most of the indicators we have in place now.

It is clear that overall landings and catch rates in LFA 34 were higher in the last 5 years relative to 1998-99 and 1999-00. Higher landings were apparent for most Grid Groups, and commercial catch rates in fall were higher in all areas. The FSRS trap data, which represents a smaller but more detailed set of data, showed a trend similar to the commercial CPUE for the Grid Groups where data were present. The other feature in the landings and catch rate data is that in several of the Grid Groups, indicators of landings and catch rates peaked between the 2001-02 and 2003-04 seasons. This trend is not captured well in the indicator tables. Some abundance indicators for lobster in adjacent areas (e.g. the U.S. trawl survey) show a downward trend in recent years.

Where the pattern of higher landings in the last 5 years was not apparent (inshore Grid Groups 1 and 2a), there is evidence of a shift in fishing effort, with more landings coming from midshore and offshore areas (see 6.2 Fishing Pressure).

Most of the indicators of abundance we have are dependent on data from fishing with traps. We should have other indicators that would be independent of changes in effort. The only non-trap data on LFA 34 lobster abundance we have available now is from the scallop survey, which includes some of the important nearshore Grid Groups. These data present a mixed picture, and more years and analysis are needed to evaluate the usefulness of the data collected.

Overall we think abundance was highest between 2001 and 2004 and may be retreating to longer term levels. Abundance is still likely well above medium (10-yr) and long-term (50-yr) means.

6.2. Fishing Pressure

Considering the period from 2000-01 to 2004-05 relative to 1998-99 and 1999-00, the average number of trap hauls and the proportion of the total traps hauled remained relatively stable in two nearshore Grid Groups but steadily declined in Grid Group 2a (Lobster Bay). The number of trap hauls increased in all of the midshore and offshore areas with the largest increase in Grid Group 4a (German Bank).

In the indicator summary table a decline in effort is given a "+" as lower effort is considered beneficial. However the reason for the decrease in effort in Grid Group 2a, traditionally the dominant area for effort and landings, is unknown. A shift of effort from this traditional area to areas further from shore could represent a concern if it reflects a change in abundance of lobsters in this important nearshore habitat.

This shift in effort away from the nearshore may also partially explain some of the problems with lobster quality (lower meat yields) in recent years. As the industry targets lobsters that tend to be larger and with a potentially different timing of the seasonal molt, a proportion of these will not have had a chance to harden up prior to harvest.

Several indicators suggest high exploitation rates. In the present fishery over 80% of the landings are newly recruited animals in the first molt group (81-94mm CL). Change-in-ratio and a depletion-based method for estimating exploitation result in estimates in nearshore areas of 70% and above. These high levels do not appear to have changed substantially since 1998-99 and 1999-00. The minimum size seems to have reduced exploitation rate in males and females in the 81-90mm size class. The extended exploitation rates are lower than the reference year, but these differences are only significantly lower in three of five years for females. Exploitation rate on the exploited population as defined by strict exploitation rates have not changed relative to the reference year. This is expected because there have been no changes in management that would be expected to affect larger sizes or the exploited part of the 81-90mm size group. Lower exploitation rates in this size range are expected from the increase in minimum legal carapace length.

The length composition analysis considers the whole of the LFA since the length frequency is weighted by landings. Using this method exploitation rate estimates are not as high but again they show no indication of a decline from the 1998-99 and 1999-00 seasons.

High exploitation rates have long been thought to be a high risk. At high exploitation the fishery relies heavily on new recruits entering the fishery. In the present fishery over 80% of the landings are newly recruited animals in the first molt group (81-94mm CL). Should recruitment decline substantially there is little buffer in the population.

6.3. Production

Pre-recruits

The FSRS recruitment trap program provides for estimates of catch rate of pre-recruits in standard traps. These estimates indicate that recruitment in an important nearshore component of LFA 34 (Grid Group 2ab) was generally higher in the last 5 years relative to 1999-00. As for legal sizes there is an indication that the fall catch rate of immediate pre-recruits (71mm CL to the MLS) peaked in 2003-04. Whether the decline in 2004-05 is the start of a longer trend is not known, but if the catch rate of 61-70mm CL is an indicator, it will continue.

The catch rate of pre-recruits from at-sea samples proved to be of limited value as an indicator of pre-recruits. Catch rates tended to be variable, likely because of the high within season variability in catch rates. If indicators for pre-recruits are to be developed from samples of the commercial catch, sampling rates must increase substantially.

In summary, we have some indicators for pre-recruits for nearshore areas (where the FSRS traps are currently concentrated) but not for the midshore and offshore areas. In addition we have no indicators for lobsters that are more than about 3 years away from reaching the legal size. Lobsters < 50mm CL are generally not well-sampled by traps, even those of FSRS design. To develop indicators for smaller lobsters, including newly settled sizes, specialized sampling programs would need to be developed. A sampling program for newly settled lobsters would mesh well with existing projects in the U.S. Gulf of Maine and in the Bay of Fundy.

Ovigerous Females

We have no reliable indicators of berried females LFA 34. They are found in very low levels in both FSRS traps and at-sea samples. We need to develop indicators of abundance for this important component of the lobster population. Out of season trap samples would increase the chances of getting enough berried females to develop a reliable indicator. We should also examine more closely indicators of females that are mature but not carrying external eggs. A re-examination of size at maturity is needed here.

6.4. Overall Stock Status

- Indicators of legal sized lobster abundance in LFA 34 were higher in the last 5 years relative to 1998-99 and 1999-00 seasons.
- Landings and catch rate appears to have peaked between 2002-03 and 2003-04.
- Overall fishing effort (number of trap hauls) is higher overall compared to the 1998-99 and 1999-00 seasons.
- There has been a shift in fishing effort from some of the inshore areas to midshore and offshore areas. The basis for this shift is unclear but is a concern.
- The shift in fishing effort away from the inshore may explain why there has been a higher proportion of low-meat yield lobsters in recent years.
- The percentage of mature females in the catch has increased as a result of fishing midshore and offshore areas with larger sizes.
- Relative to the late 1990s the stock is still fished at high levels with estimates for inshore areas on the order of 70% and higher. High effort and high removal rates continue to be a concern. The fishery is still highly dependent on new recruits.
- A CPUE index for pre-recruit sizes in FSRS traps in a nearshore portion of LFA 34 was higher compared to 1999-00, but has trended downwards in the last 1-2 years and is now at levels similar to 1999-2000.
- There is uncertainty whether the significance of shifts in size structure offshore are due to higher recruitment in these areas or fishing down.

6.5. Recommended Indicators For Monitoring the Future Health of the Lobster Stocks

- The number and type of indicators of abundance and production should be expanded.
- The current LFA 34 log books are essential and provide the basis for current indicators of abundance and fishing pressure. High participation rates among fishermen and keeping accurate log records is essential. Data entry must be accurate and timely.
- Spatial distribution indicators of fishing effort should be developed from the location data provided in LFA 34 log books.
- An indicator of fishing efficiency is needed. Ideally this indicator would capture improvements in boats, navigation, traps etc.
- Fishery-independent indicators of abundance are needed. Full advantage should be made of surveys that catch lobsters in towed gear.
- The FSRS recruitment trap project should be maintained and if possible expanded to more participants. It forms the basis for recruitment indicators that appear to have some reliability down to about 60mm CL.
- Indicators of pre-recruits are needed for midshore and offshore areas since these areas are less amenable to the FSRS type trapping protocol. One possibility is to collect recruitment type data from commercial traps.

- Indicators for berried females would be useful to estimate reproductive output directly and to track this important component of the population. Recording berried females during commercial fishing in some areas may form the basis for one indicator. Some form of sampling outside of the season is likely needed to get a reliable indicator of berried females.
- Indicators of juveniles that are more than 3 years away from reaching fishable sizes (< approx 50mm CL). Such indicators would give advance warning of downturns in recruitment. An indicator for newly-settled lobsters could be developed with specialized sampling.
- Ecosystem indicators – Physical environment - Long-term temperature monitoring throughout the season is essential.

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TABLES

Table 2.5.1 No of FSRS participants in recruitment trap project within LFA34

Season	No. participants
19981999	3
19992000	24
20002001	37
20012002	39
20022003	42
20032004	41
20042005	45

Table 2.5.2 FSRS recruitment trap project within LFA 34 Grid Groups 1, 2a and 2b. Shown are number of trap hauls and total number recorded by size/sex group.

Grid Group 1.

```
> aggregate(fsrsnfe.g1[5:15],list(season=fsrsnfe.g1$season),sum)
    season sumthauls sumlt51 sum5160 sum6170 sum71mls summls90 sum91100 sumgt101 sumblt81 sumb81100 sumbgt101
1 19992000       400     147     417     640      850      230       68        9        0         2         0
2 20002001      1095     248     658    1717     3069      797      331       73        0        37         1
3 20012002       828     189     604    1656     3359      687      231       30        0        22         2
4 20022003       824     199     596    1303     2419      645      265       67       11        12         1
5 20032004       581     177     448     849     1492      489      251       65        0         0         0
6 20042005      1637     520    1147    2120     4366     1020      428      102        0         0         0
```

Grid Group 2a

```
> aggregate(fsrsnfe.g2a[5:15],list(season=fsrsnfe.g2a$season),sum)
    season sumthauls sumlt51 sum5160 sum6170 sum71mls summls90 sum91100 sumgt101 sumblt81 sumb81100 sumbgt101
1 19992000       734     184     651     982     1795      416      108       29        0         4         1
2 20002001      1807     203     972    2391     4857     1013      429       90        5        48        10
3 20012002      1841     552    1363    3362     8436     1192      700      193       11        57        11
4 20022003      1867     246     985    2786     6521     1062      407       97       14        25         4
5 20032004      1280     505     711    1492     2998      596      301      135        0         0         0
6 20042005      1289     540     659    1423     3655      673      274      137        0         0         0
```

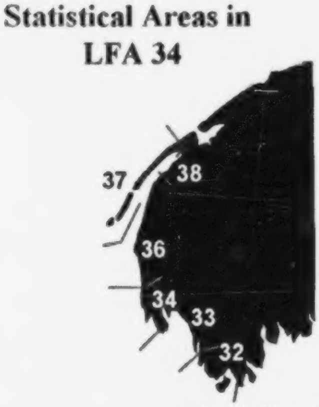
Grid Group 2b

```
> aggregate(fsrsnfe.g2b[5:15],list(season=fsrsnfe.g2b$season),sum)
    season sumthauls sumlt51 sum5160 sum6170 sum71mls summls90 sum91100 sumgt101 sumblt81 sumb81100 sumbgt101
1 19992000      1322     106     344     759     1767      643      252       81        7        10        12
2 20002001      1394      70     314     816     2238      624      503      158        1        31        19
3 20012002      1420     143     458     915     2816      686      689      176        3        22        15
4 20022003      1487      67     265     931     2734      995      552      119        2        41        14
5 20032004      1142     185     280     681     1942      834      589      228        0         0         0
6 20042005      1622     288     276     654     2056      724      743      415        0         0         0
```

Table 3.1.1 LFA34 Landings 1974-75 to 2004-05

SEASON	Landings (metric tons)	Source
1974-75	3973	Sales-slips
1975-76	3914	Sales-slips
1976-77	3463	Sales-slips
1977-78	2813	Sales-slips
1978-79	3037	Sales-slips
1979-80	3229	Sales-slips
1980-81	3060	Sales-slips
1981-82	3663	Sales-slips
1982-83	4546	Sales-slips
1983-84	5138	Sales-slips
1984-85	5938	Sales-slips
1985-86	6891	Sales-slips
1986-87	7673	Sales-slips
1987-88	8479	Sales-slips
1988-89	8201	Sales-slips
1989-90	9449	Sales-slips
1990-91	11071	Sales-slips
1991-92	8876	Sales-slips
1992-93	8916	Sales-slips
1993-94	10326	Sales-slips
1994-95	9692	Sales-slips
1995-96	10307	Self reporting
1996-97	10593	Self reporting
1997-98	11886	Self reporting
1998-99	12993	LFA 34 log book
1999-2000	13514	LFA 34 log book
2000-2001	16503	LFA 34 log book
2001-2002	19284	LFA 34 log book
2002-2003	19000	LFA 34 log book
2003-2004	18955	LFA 34 log book
2004-2005	Preliminary 17007	LFA 34 log book

Table 3.1.2 Landings By Statistical Districts 1981-2005

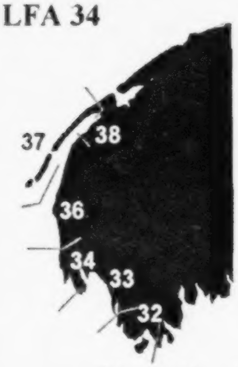


StatisticalAreaLandings(mt)

Season	32	33	34	36	37	38	TOTAL
1981-82	1261	929	1044	148	265	16	3663
1982-83	1475	1365	1167	186	346	20	4559
1983-84	1636	1525	1421	200	351	22	5155
1984-85	2249	1772	1305	187	421	17	5951
1985-86	2580	2000	1515	292	496	16	6899
1986-87	2951	2127	1707	317	561	18	7681
1987-88	3185	2109	1960	399	581	13	8247
1988-89	2421	2516	2231	425	626	8	8228
1989-90	3297	2748	2403	458	546	2	9455
1990-91	4032	3291	2503	501	738	5	11071
1991-92	2839	2746	2132	506	644	8	8876
1992-93	2724	2902	2108	497	683	3	8916
1993-94	3776	2795	2512	515	729	0	10326
1994-95	3456	2689	2394	445	708	0	9692
1995-96	3728	3002	2039	698	831	16	10314
1996-97	3989	2748	2164	868	813	22	10604
1997-98	4357	3171	2520	1005	828	9	11890
1998-99	4145	3491	2734	1035	878	19	12303
1999-00	4445	4029	3037	1056	977	32	13576
2000-01	5433	5204	3255	1220	1213	29	16353
2001-02	6353	6004	3838	1369	1384	9	18957
2002-03	6177	5692	3014	1313	1423	47	17666
2003-04	6213	5747	3249	1162	1494	51	17916
2004-05 (preliminary)	5517	5015	3046	1401	1592	50	16622

Table 3.1.2 Landings By Statistical Districts 1981-2005

Statistical Areas in LFA 34



StatisticalAreaLandings(mt)

Season	32	33	34	36	37	38	TOTAL
1981-82	1261	929	1044	148	265	16	3663
1982-83	1475	1365	1167	186	346	20	4559
1983-84	1636	1525	1421	200	351	22	5155
1984-85	2249	1772	1305	187	421	17	5951
1985-86	2580	2000	1515	292	496	16	6899
1986-87	2951	2127	1707	317	561	18	7681
1987-88	3185	2109	1960	399	581	13	8247
1988-89	2421	2516	2231	425	626	8	8228
1989-90	3297	2748	2403	458	546	2	9455
1990-91	4032	3291	2503	501	738	5	11071
1991-92	2839	2746	2132	506	644	8	8876
1992-93	2724	2902	2108	497	683	3	8916
1993-94	3776	2795	2512	515	729	0	10326
1994-95	3456	2689	2394	445	708	0	9692
1995-96	3728	3002	2039	698	831	16	10314
1996-97	3989	2748	2164	868	813	22	10604
1997-98	4357	3171	2520	1005	828	9	11890
1998-99	4145	3491	2734	1035	878	19	12303
1999-00	4445	4029	3037	1056	977	32	13576
2000-01	5433	5204	3255	1220	1213	29	16353
2001-02	6353	6004	3838	1369	1384	9	18957
2002-03	6177	5692	3014	1313	1423	47	17666
2003-04	6213	5747	3249	1162	1494	51	17916
2004-05 (preliminary)	5517	5015	3046	1401	1592	50	16622

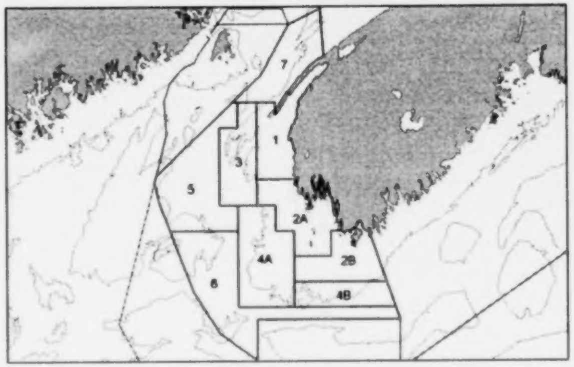


Table 3.1.3 Landings (pounds) from LFA 34 log books by time period and Grid Groups

Time period		1	2a	2b	3	4a	4b	5	6	7	Total (pounds)	Total Metric tons
Total	1998-99	5,355,641	12,219,673	3,775,846	789,729	1,405,840	197,340	251,250	144,178	470,184	24,611,679	11,164
	1999-00	5,053,311	11,593,210	3,971,674	620,278	2,525,902	180,678	281,413	272,865	365,601	24,866,930	11,279
	2000-01	6,174,890	12,948,097	5,359,439	1,340,011	4,087,351	433,155	311,013	458,491	432,734	31,547,180	14,310
	2001-02	6,614,756	14,295,832	5,659,497	1,586,494	5,300,855	618,070	534,692	747,543	534,504	35,894,245	16,281
	2002-03	6,180,931	11,494,066	6,002,800	1,285,969	5,220,524	911,057	753,920	727,270	589,893	33,168,432	15,045
	2003-04	5,497,644	10,569,473	5,430,372	1,736,797	5,530,425	1,089,388	1,157,368	1,522,798	774,088	33,310,355	15,109
	2004-05	6,403,460	9,582,889	6,129,989	1,779,071	4,171,583	549,898	562,293	968,905	993,350	31,143,442	14,126
Fall	1998-99	2,412,457	6,333,221	2,188,015	415,985	761,835	91,684	125,161	7,885	160,155	12,498,396	5,669
	1999-00	2,684,553	7,070,430	2,353,611	432,642	1,783,161	86,359	143,773	102,297	146,088	14,804,915	6,715
	2000-01	3,599,002	7,152,810	2,958,838	913,599	2,565,362	236,604	216,592	230,851	192,408	18,068,068	8,196
	2001-02	4,220,643	8,725,695	3,550,220	1,125,947	3,788,014	375,737	357,269	432,376	256,024	22,833,927	10,357
	2002-03	3,858,440	6,094,684	3,061,996	1,019,672	3,736,352	497,072	546,696	459,300	248,765	19,524,979	8,856
	2003-04	3,271,636	5,957,303	3,107,150	1,188,126	3,855,216	699,622	758,133	985,560	356,452	20,181,200	9,154
	2004-05	3,501,007	4,672,009	3,036,629	1,280,920	3,005,671	351,366	287,557	553,882	346,608	17,037,652	7,728

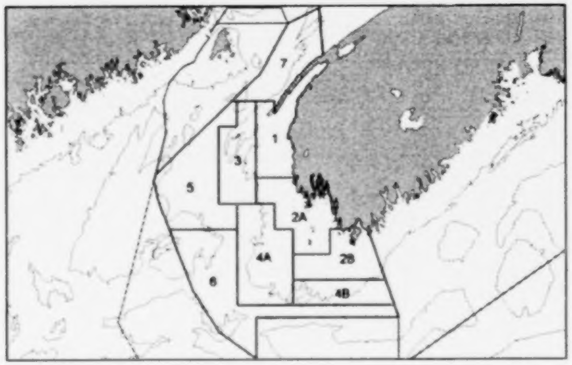


Table 3.1.3 (continued) Landings (pounds) from LFA 34 log books by time period and Grid Groups

Time period		1	2a	2b	3	4a	4b	5	6	7	Total (pounds)	Total Metric tons
First 2 weeks fall	1998-99	1,825,806	5,169,939	1,734,584	260,551	575,199	68,239	91,051	1,860	108,180	9,837,407	4,462
	1999-00	2,007,751	5,583,380	1,696,758	258,177	1,321,520	49,998	111,265	27,490	93,868	11,152,207	5,059
	2000-01	2,887,932	5,942,064	2,342,933	660,338	1,886,432	141,722	163,537	101,166	118,978	14,247,103	6,462
	2001-02	3,272,073	6,874,645	2,696,171	859,021	2,789,631	222,624	247,596	266,315	148,904	17,378,981	7,883
	2002-03	2,604,661	4,097,036	1,852,890	630,087	2,310,935	244,570	302,475	186,484	125,502	12,356,642	5,605
	2003-04	2,294,895	4,173,397	2,111,165	735,979	2,467,309	349,921	454,679	518,547	121,401	13,229,296	6,001
	2004-05	2,664,461	3,559,952	2,140,377	914,869	2,251,764	246,514	194,423	364,768	176,937	12,516,069	5,677

Dec.	1998-99	586,651	1,163,281	453,431	155,434	186,636	23,445	34,110	6,025	51,975	2,662,987	1,208
	1999-00	676,802	1,487,050	656,853	174,465	461,641	36,361	32,508	74,807	52,220	3,654,706	1,658
	2000-01	711,070	1,210,747	615,905	253,261	678,930	94,882	53,055	129,685	73,430	3,822,965	1,734
	2001-02	948,570	1,851,050	854,049	266,926	998,384	153,112	109,673	166,061	107,120	5,456,946	2,475
	2002-03	1,253,779	1,997,648	1,209,106	389,585	1,425,417	252,502	244,221	272,816	123,263	7,170,339	3,252
	2003-04	976,741	1,783,906	995,985	452,147	1,387,907	349,701	303,454	467,013	235,051	6,953,907	3,154
	2004-05	836,545	1,112,057	896,252	366,051	753,907	104,852	93,134	189,114	169,671	4,523,587	2,052

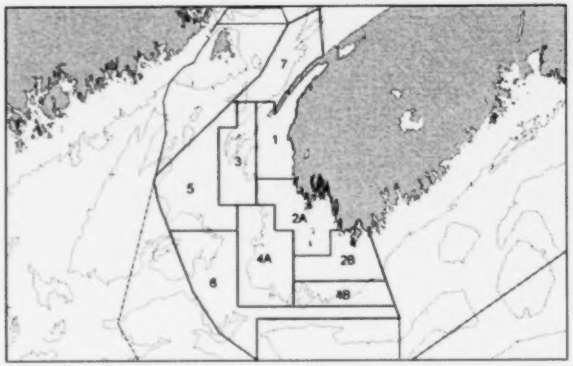


Table 3.1.3 (continued) Landings (pounds) from LFA 34 log books by time period and Grid Groups

Time period		1	2a	2b	3	4a	4b	5	6	7	Total (pounds)	Total Metric tons
Winter	1998-99	789,172	1,254,210	275,560	215,207	187,062	48,742	64,036	100,623	112,456	3,049,066	1,383
	1999-00	682,379	1,244,296	386,762	109,058	317,317	33,233	80,853	125,811	110,743	3,092,453	1,403
	2000-01	754,456	1,259,930	490,426	251,231	596,130	76,898	78,920	157,140	113,543	3,780,675	1,715
	2001-02	815,104	1,190,302	390,460	261,792	624,108	97,140	113,726	229,618	169,821	3,894,072	1,766
	2002-03	527,707	683,378	595,250	125,493	504,827	104,186	150,431	170,704	167,500	3,031,478	1,375
	2003-04	606,805	849,487	524,543	311,031	772,434	159,067	312,591	427,880	235,486	4,201,327	1,906
	2004-05	719,620	793,841	613,874	297,908	396,351	88,517	156,954	311,011	309,165	3,689,245	1,673
Spring	1998-99	2,154,012	4,632,242	1,312,271	158,537	456,944	56,913	62,052	35,670	197,572	9,068,212	4,113
	1999-00	1,686,378	3,278,484	1,231,301	78,577	425,424	61,085	56,787	44,756	108,769	6,973,561	3,163
	2000-01	1,821,433	4,535,357	1,910,174	175,180	925,858	119,652	15,501	70,499	126,783	9,702,437	4,401
	2001-02	1,579,009	4,379,835	1,718,817	198,755	888,733	145,193	63,697	85,549	108,659	9,170,248	4,160
	2002-03	1,794,784	4,716,004	2,345,554	140,804	979,345	309,799	56,793	97,266	173,628	10,615,979	4,815
	2003-04	1,619,203	3,762,683	1,798,679	237,640	902,775	230,699	86,644	109,358	182,150	8,931,834	4,051
	2004-05	2,182,833	4,117,040	2,479,486	200,243	769,561	110,015	117,782	104,012	337,577	10,420,553	4,727

Table 3.1.4 Proportion of total catch by Grid Groups

	Grid Group 1	Grid Group 2a	Grid Group 2b	Grid Group 3	Grid Group 4a	Grid Group 4b	Grid Group 5	Grid Group 6	Grid Group 7	Nearshore	Midshore / Offshore
1998-99	0.22	0.50	0.15	0.03	0.06	0.01	0.01	0.01	0.02	0.87	0.11
1999-00	0.20	0.47	0.16	0.02	0.10	0.01	0.01	0.01	0.01	0.83	0.16
2000-01	0.20	0.41	0.17	0.04	0.13	0.01	0.01	0.01	0.01	0.78	0.21
2001-02	0.18	0.40	0.16	0.04	0.15	0.02	0.01	0.02	0.01	0.74	0.24
2002-03	0.19	0.35	0.18	0.04	0.16	0.03	0.02	0.02	0.02	0.71	0.27
2003-04	0.17	0.32	0.16	0.05	0.17	0.03	0.03	0.05	0.02	0.65	0.33
2004-05	0.21	0.31	0.20	0.06	0.13	0.02	0.02	0.03	0.03	0.71	0.26

Table 3.2.1 Catch (pounds) per trap haul from LFA 34 log books by Grid Groupings and fishing period

		Grid Groups								
	Season	1	2a	2b	3	4a	4b	5	6	7
First 2 weeks	1998-99	3.1	3.2	2.6	3.6	2.7	2.5	3.1	2.6	2.8
	1999-00	3.9	4.5	3.5	5.5	6.2	3.6	4.8	6.1	3.4
	2000-01	5.1	4.5	4.2	6.8	6.3	5.3	5.3	6.5	3.8
	2001-02	5.3	4.7	4.4	6.4	6.4	4.9	5.9	6.3	4.7
	2002-03	6.3	4.8	4.6	6.8	7.2	6.5	8.4	6.2	4.6
	2003-04	6.1	5.4	5.7	7.2	7.9	7.3	8.1	8.1	6.1
	2004-05	5.1	4.5	4.5	5.9	5.6	6.1	5.0	5.9	5.4
December	1998-99	1.6	1.3	1.1	2.7	1.5	1.2	1.5	1.9	1.8
	1999-00	1.6	1.6	1.5	2.9	2.8	1.7	2.1	3.6	2.8
	2000-01	2.1	1.9	2.1	4.2	4.0	3.8	2.8	5.9	2.9
	2001-02	2.2	2.0	2.1	3.5	3.8	3.3	4.0	4.4	4.7
	2002-03	3.0	2.4	2.9	4.4	4.9	5.2	7.1	4.8	3.1
	2003-04	2.4	2.3	2.5	3.5	4.6	4.3	4.7	5.6	4.6
	2004-05	2.4	1.8	2.2	3.0	2.9	2.9	3.2	3.5	3.5
Winter	1998-99	0.7	0.7	0.6	1.7	1.0	1.0	1.3	1.7	0.9
	1999-00	0.7	0.6	0.7	1.3	1.2	0.8	1.1	1.7	1.2
	2000-01	0.8	0.7	0.8	1.4	1.4	0.9	1.5	2.0	1.1
	2001-02	0.8	0.7	0.8	1.5	1.5	1.5	1.4	2.0	2.1
	2002-03	0.9	0.7	1.0	1.1	1.4	1.3	2.0	1.8	1.5
	2003-04	1.0	1.0	1.2	1.8	2.1	2.0	2.0	2.7	1.9
	2004-05	0.9	0.8	1.0	1.3	1.1	1.0	1.7	1.9	1.6
Spring	1998-99	1.1	0.9	0.7	1.3	0.9	0.8	1.0	1.2	1.3
	1999-00	0.9	0.8	0.8	0.9	0.9	0.9	0.8	0.9	1.0
	2000-01	0.9	0.9	0.9	0.9	1.0	0.9	0.7	0.9	1.0
	2001-02	1.0	1.0	1.0	1.0	1.2	1.2	0.9	1.1	1.3
	2002-03	0.9	1.0	1.1	0.8	1.0	1.3	0.8	0.9	1.2
	2003-04	0.9	0.9	1.0	1.0	1.0	1.1	0.9	1.1	1.3
	2004-05	1.0	0.9	1.0	0.9	0.8	1.0	0.9	1.2	1.5

Table 3.3.1 Number of LFA 34 log book records used in model of catch rate for each combination of Grid Group and period. Each period has data for the fishing seasons 1998-99 through to 2004-05.

		No. records		
Grid Group	Period	cleaned set	>5 d & max	used in model
1	Fall	19911	18800	18779
2a	Fall	42907	39698	39594
2b	Fall	21487	19043	19019
3	Fall	3928	3648	3647
4a	Fall	11979	11298	11290
4b	Fall	1839	1768	1767
5	Fall	1461	1245	1245
6	Fall	1610	1438	1438
7	Fall	1745	1621	1620
1	Winter	20062	19709	19462
2a	Winter	32284	30803	30123
2b	Winter	13562	12625	12301
3	Winter	3391	3191	3115
4a	Winter	7884	7252	7159
4b	Winter	1789	1508	1496
5	Winter	1752	1565	1533
6	Winter	2378	2160	2136
7	Winter	3623	3574	3549
1	Spring	40353	37308	37184
2a	Spring	97236	86607	86066
2b	Spring	44703	36859	36570
3	Spring	3633	3487	3469
4a	Spring	16520	15621	15519
4b	Spring	3221	2967	2955
5	Spring	1556	1528	1509
6	Spring	1610	1479	1468
7	Spring	4147	3704	3693
	TOT	406571	370506	367706
	% of cleaned data set	100%	91%	90%
	% of all records	85%	78%	77%
	No. of records in cleaned data set =			406571
	No. of total records =			475932

Table 3.3.2 Output from mixed effect model on test data set (Grid Group 2a, fall period). Note that licenses with fewer than 5 days and ≥ 35 days were not removed from the data set prior to this run.

a) Model estimates

```
> summary(logdata2.2.lme,corr=F)
Linear mixed-effects model fit by REML
 Data: logtestdata
  Subset: CPUE > 50/375
       AIC      BIC    logLik
  61446.26 61550.23 -30711.13

Random effects:
 Formula:  ~ 1 + seasonday | licnew3.char
 Structure: General positive-definite
               StdDev    Corr
(Intercept) 0.23622218 (Inter
  seasonday 0.01639046 -0.053
   Residual 0.48023892

Fixed effects: log(CPUE) ~ seasonday + yr
                Value  Std.Error    DF   t-value p-value
(Intercept)  1.352708 0.01198190 42183  112.8959  <.0001
  seasonday -0.051255 0.00076551 42183  -66.9549  <.0001
     yr1999  0.288821 0.00821633 42183   35.1521  <.0001
     yr2000  0.322235 0.00846703 42183   38.0576  <.0001
     yr2001  0.420853 0.00821521 42183   51.2285  <.0001
     yr2002  0.464264 0.00898636 42183   51.6632  <.0001
     yr2003  0.524245 0.00941919 42183   55.6572  <.0001
     yr2004  0.270065 0.00978562 42183   27.5981  <.0001

Standardized Within-Group Residuals:
       Min         Q1         Med         Q3      Max
 -6.797363 -0.5451943 0.02238577 0.5694945 6.16398

Number of Observations: 42799
Number of Groups: 609
```

b)

```
Test Random effects for model 1+seasonday+yr

    Model   df   AIC       BIC      logLik   Test L.Ratio   p-value
Without   1  9 74261.96 74339.93 -37121.98
With      2 12 61446.26 61550.23 -30711.13 1 vs 2 12821.7  <.0001


Test Fixed effects:
```

Term	numDF	denDF	F-value	p-value
(Intercept)	1	42183	19130.00	<.0001
seasonday	1	42183	4432.07	<.0001
year	6	42183	762.29	<.0001

Table 3.3.3 Output from mixed effect model on test data set (Grid Group 2a, fall period) with global intercept removed. Same data as Table 3.3.2.

```
Linear mixed-effects model fit by REML
 Data: logsallfg2a
  Subset: CPUE > 50/375
       AIC      BIC    logLik
  61446.26 61550.23 -30711.13

Random effects:
 Formula: ~1 + seasonday | licnew3
 Structure: General positive-definite, Log-Cholesky parameterization
            StdDev     Corr
(Intercept) 0.23622221 (Intr)
seasonday   0.01639046 -0.053
Residual    0.48023892

Fixed effects: log(CPUE) ~ -1 + seasonday + yr
               Value   Std.Error    DF   t-value p-value
seasonday -0.0512548 0.000765512 42183 -66.95489       0
yr1998     1.3527081 0.011981905 42183 112.89591       0
yr1999     1.6415291 0.012310651 42183 133.34219       0
yr2000     1.6749429 0.012370233 42183 135.40108       0
yr2001     1.7735611 0.012237230 42183 144.93157       0
yr2002     1.8169725 0.012868828 42183 141.19176       0
yr2003     1.8769534 0.013115684 42183 143.10755       0
yr2004     1.6227729 0.013339765 42183 121.64929       0

Standardized Within-Group Residuals:
        Min          Q1         Med          Q3         Max
-6.79736342 -0.54519426  0.02238577  0.56949449  6.16398007

Number of Observations: 42799
Number of Groups: 609
>
```

Table 3.4.1 Anova table for FSRS CPUE (no. per trap haul) of legal sized lobsters, Grid Group 2ab, fall. Cpue is no. of lobsters per trap haul per week. Of a total of 701 records, 223 were removed because there were 0 legal size lobsters recorded.

Shown below the anova are statistics associated with the model coefficients for Season.

```
Analysis of Variance Table
Response: log(legal/Hauls)
                     Df  Sum Sq Mean Sq  F value    Pr(>F)
week                  1  99.237  99.237 268.8050 < 2.2e-16 ***
factor(Season)        5   8.144   1.629   4.4118 0.0005914 ***
factor(VesselCode)   44  98.276   2.234   6.0500 < 2.2e-16 ***
Residuals           608 224.460   0.369
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

----------------------

summary(fsrsmfbgrp.2ab.fall.legal.lm1)

Call:
lm(formula = log(legal/Hauls) ~ 1 + (week) + factor(Season) +
    factor(VesselCode), data = fsrsmfbgrp.2ab.fall, subset =
legal/Hauls > 0)

Residuals:
     Min       1Q   Median       3Q      Max
-2.47175 -0.32131  0.02226  0.37837  1.92332

Coefficients:
                       Estimate Std. Error t value Pr(>|t|)
(Intercept)             0.97341    0.14231   6.840 1.94e-11 ***
week                   -0.29130    0.01745 -16.691  < 2e-16 ***
factor(Season)20002001  0.07346    0.09456   0.777 0.437508
factor(Season)20012002  0.31601    0.09371   3.372 0.000793 ***
factor(Season)20022003  0.29027    0.09934   2.922 0.003609 **
factor(Season)20032004  0.36781    0.10052   3.659 0.000275 ***
factor(Season)20042005  0.11442    0.10204   1.121 0.262576
------------------------------------------------
```

Table 3.4.2 Anova table for FSRS CPUE (no. per trap haul) of legal sized lobsters, Grid Group 2ab, spring. Cpue is no. of lobsters per trap haul per week. Of a total of 1332 records, 179 were removed because there were 0 legal size lobsters recorded. Week2 is set such that week2=1 when actual season week is week 19.

Shown below the anova are statistics associated with the model coefficients for Season.

Analysis of Variance Table

```
Response: log(legal/Hauls)
                      Df Sum Sq Mean Sq  F value    Pr(>F)
week2                  1  52.07   52.07 127.4435 < 2.2e-16 ***
factor(Season)         5  11.19    2.24   5.4794 5.458e-05 ***
factor(VesselCode)    45  94.50    2.10   5.1398 < 2.2e-16 ***
Residuals           1101 449.86    0.41
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

> summary(fsrsmfbgrp.2ab.sprg.legal.lm1)

Call:
lm(formula = log(legal/Hauls) ~ 1 + (week2) + factor(Season) +
    factor(VesselCode), data = fsrsmfbgrp.2ab.sprg, subset = legal/Hauls
> 0)

Residuals:
     Min       1Q   Median       3Q      Max
-2.28433 -0.40842  0.06287  0.43645  2.01412

Coefficients:
                          Estimate Std. Error  t value Pr(>|t|)
(Intercept)             -1.049e+00  1.098e-01   -9.558  < 2e-16 ***
week2                    8.494e-02  7.690e-03   11.045  < 2e-16 ***
factor(Season)20002001  2.877e-01  7.678e-02    3.747 0.000188 ***
factor(Season)20012002  1.780e-01  7.726e-02    2.304 0.021399 *
factor(Season)20022003  2.648e-01  7.867e-02    3.365 0.000791 ***
factor(Season)20032004  3.243e-01  7.984e-02    4.062 5.20e-05 ***
factor(Season)20042005  1.729e-01  8.203e-02    2.108 0.035271 *
```

Table 4.1 Trap Hauls from LFA 34 log book data

		Grid Groups									
	Season	**1**	**2a**	**2b**	**3**	**4a**	**4b**	**5**	**6**	**7**	**Total**
Total	1998-99	3,641,607	8,712,539	2,965,280	319,889	892,997	150,068	141,605	91,944	315,147	17,231,076
	1999-00	3,260,294	7,482,117	2,649,184	217,512	960,082	125,543	167,483	129,308	233,141	15,224,664
	2000-01	3,658,717	8,324,049	3,237,169	465,303	1,683,579	239,446	105,972	176,686	260,818	18,151,739
	2001-02	3,211,228	7,537,615	2,903,866	505,160	1,573,057	236,514	191,489	235,291	193,755	16,587,975
	2002-03	2,942,907	6,630,234	3,039,434	379,687	1,693,429	365,347	182,045	225,591	284,695	15,743,369
	2003-04	2,809,565	5,811,279	2,658,713	498,978	1,599,945	338,466	312,063	325,722	289,689	14,644,420
	2004-05	3,530,142	6,556,461	3,569,986	601,428	1,667,104	231,840	262,071	315,895	453,901	17,188,828
First 2 weeks	1998-99	583,667	1,620,602	664,406	71,402	210,969	27,371	29,644	709	39,127	3,247,897
	1999-00	520,478	1,247,953	481,577	47,208	214,494	13,960	23,040	4,513	27,287	2,580,510
	2000-01	563,661	1,325,663	556,068	97,342	298,027	26,569	31,000	15,637	31,588	2,945,555
	2001-02	612,896	1,447,925	616,346	134,210	434,343	45,681	42,098	42,400	31,360	3,407,259
	2002-03	413,094	857,737	401,126	92,530	320,014	37,478	35,984	29,862	27,421	2,215,246
	2003-04	376,548	778,052	371,693	102,004	313,758	47,850	56,477	64,217	19,986	2,130,585
	2004-05	524,298	791,901	478,012	154,631	402,986	40,346	38,824	61,978	32,953	2,525,929
December	1998-99	374,736	911,867	404,097	56,715	127,689	20,194	22,382	3,207	28,812	1,949,699
	1999-00	422,193	914,797	428,837	59,242	164,670	21,067	15,638	20,622	18,800	2,065,866
	2000-01	344,002	640,720	293,958	60,324	171,653	25,211	18,722	22,132	25,595	1,602,317
	2001-02	423,137	903,586	414,031	75,922	264,071	45,988	27,586	37,337	22,890	2,214,548
	2002-03	419,034	849,954	411,366	88,799	289,731	48,801	34,408	57,261	39,442	2,238,796
	2003-04	402,096	788,346	406,512	128,852	304,343	80,734	64,843	82,966	51,577	2,310,269
	2004-05	354,905	615,689	414,514	121,894	262,256	36,724	29,467	53,939	48,631	1,938,019
Winter	1998-99	1,067,016	1,875,545	462,254	124,958	193,123	50,491	51,196	60,715	126,120	4,011,418
	1999-00	954,378	1,988,545	549,611	81,645	273,457	40,600	72,770	72,377	92,435	4,125,818
	2000-01	988,877	1,782,010	634,331	174,374	440,223	84,394	51,607	80,501	106,965	4,343,282
	2001-02	974,834	1,600,022	503,525	179,943	414,644	65,990	79,908	113,871	80,350	4,013,087
	2002-03	619,633	942,451	584,966	114,447	368,589	82,647	76,603	92,470	112,716	2,994,522
	2003-04	622,975	847,297	447,319	170,046	360,705	77,759	155,021	158,558	124,607	2,964,287
	2004-05	793,643	1,007,761	601,556	222,775	352,502	85,488	90,118	166,349	189,948	3,510,140
Spring	1998-99	1,990,924	5,216,392	1,838,620	123,529	488,905	72,206	60,765	30,520	149,900	9,971,761
	1999-00	1,785,438	4,245,619	1,617,996	88,659	472,131	70,983	71,673	52,418	113,419	8,518,336
	2000-01	2,106,179	5,216,376	2,046,770	193,587	945,329	128,483	23,365	80,548	122,265	10,862,902
	2001-02	1,623,498	4,489,668	1,783,995	191,007	724,070	124,843	69,483	79,020	82,045	9,167,629
	2002-03	1,910,180	4,830,046	2,053,342	172,710	1,004,826	245,222	69,458	103,259	144,558	10,533,601
	2003-04	1,810,042	4,185,930	1,839,701	226,928	925,482	212,857	100,565	102,947	145,096	9,549,548
	2004-05	2,212,201	4,756,799	2,490,418	224,022	911,616	106,006	133,129	87,568	231,000	11,152,759

Table 4.2.1 Number and % in molt groups 1,2,3+ and > than size at 50% maturity, by Grid Group

Grid Group		1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05
1	# Molt Group 1	3,845,256	3,646,729	3,605,986	4,060,621	3,793,602	3,469,613	3,903,649
	# Molt Group 2	556,584	532,917	767,231	724,059	681,359	634,171	654,628
	# Molt Group 3+	83,869	75,077	161,773	173,988	144,040	150,294	173,649
	> Size at 50% maturity	439,675	414,765	791,021	741,458	695,925	643,946	706,999
	% Molt Group 1	82.7%	82.6%	74.6%	76.5%	76.9%	77.0%	77.3%
	%Molt Group 2	12.0%	12.1%	15.9%	13.6%	13.8%	14.1%	13.0%
	%Molt Group 3+	1.8%	1.7%	3.3%	3.3%	2.9%	3.3%	3.4%
	% > Size at 50% maturity	9.5%	9.4%	16.4%	14.0%	14.1%	14.3%	14.0%
2a	# Molt Group 1	9,148,673	8,774,457	9,129,712	9,620,058	7,102,511	6,578,350	6,380,396
	# Molt Group 2	1,030,892	801,241	1,333,783	1,266,523	1,080,556	1,060,870	804,960
	# Molt Group 3+	329,258	223,534	220,404	306,664	459,665	371,184	287,040
	> Size at 50% maturity	1,028,932	740,276	1,295,155	1,300,256	1,306,957	1,209,343	926,640
	% Molt Group 1	84.1%	84.9%	79.8%	80.8%	77.7%	76.1%	79.6%
	%Molt Group 2	9.5%	7.8%	11.7%	10.6%	11.8%	12.3%	10.0%
	%Molt Group 3+	3.0%	2.2%	1.9%	2.6%	5.0%	4.3%	3.6%
	% > Size at 50% maturity	9.5%	7.2%	11.3%	10.9%	14.3%	14.0%	11.6%
2b	# Molt Group 1	2,314,455	2,594,051	2,811,293	3,007,963	3,593,770	3,492,562	3,737,682
	# Molt Group 2	503,257	467,041	850,327	932,164	726,935	650,133	779,234
	# Molt Group 3+	113,696	88,000	132,587	150,568	114,196	95,687	139,777
	> Size at 50% maturity	491,800	415,100	859,165	951,620	688,585	595,583	758,322
	% Molt Group 1	77.5%	79.9%	71.3%	70.8%	78.4%	79.9%	78.1%
	%Molt Group 2	16.9%	14.4%	21.6%	21.9%	15.9%	14.9%	16.3%
	%Molt Group 3+	3.8%	2.7%	3.4%	3.5%	2.5%	2.2%	2.9%
	% > Size at 50% maturity	16.5%	12.8%	21.8%	22.4%	15.0%	13.6%	15.8%
3	# Molt Group 1	297,313	211,831	476,053	819,141	654,512	910,793	950,822
	# Molt Group 2	147,949	131,811	255,565	253,574	206,191	279,428	294,168
	# Molt Group 3+	66,542	60,890	87,138	51,836	43,543	57,319	62,078
	> Size at 50% maturity	186,884	168,206	307,068	253,014	208,726	281,721	297,287
	% Molt Group 1	58.3%	52.6%	56.7%	70.7%	70.3%	70.9%	70.7%
	%Molt Group 2	29.0%	32.7%	30.4%	21.9%	22.1%	21.7%	21.9%
	%Molt Group 3+	13.0%	15.1%	10.4%	4.5%	4.7%	4.5%	4.6%
	% > Size at 50% maturity	36.6%	41.8%	36.6%	21.8%	22.4%	21.9%	22.1%
4a	# Molt Group 1	777,978	1,453,341	2,564,743	3,306,353	3,362,339	3,720,022	2,777,536
	# Molt Group 2	213,735	364,275	446,156	527,581	473,209	481,636	368,222
	# Molt Group 3+	45,591	80,072	99,729	112,958	126,514	132,246	101,579
	> Size at 50% maturity	203,579	340,215	460,591	532,897	504,838	504,493	384,729
	% Molt Group 1	73.4%	74.8%	78.7%	80.2%	79.3%	80.2%	80.4%
	%Molt Group 2	20.2%	18.7%	13.7%	12.8%	11.2%	10.4%	10.7%
	%Molt Group 3+	4.3%	4.1%	3.1%	2.7%	3.0%	2.9%	2.9%
	% > Size at 50% maturity	19.2%	17.5%	14.1%	12.9%	11.9%	10.9%	11.1%

Grid Group		1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05
4b	# Molt Group 1	88,250	76,131	209,317	291,082	420,974	529,441	280,976
	# Molt Group 2	42,016	36,246	79,757	110,913	160,407	201,737	107,062
	# Molt Group 3+	9,449	8,152	18,347	25,515	36,902	46,409	24,629
	> Size at 50% maturity	39,316	33,917	87,245	121,327	175,470	220,679	117,115
	% Molt Group 1	63.2%	63.2%	67.5%	67.5%	67.5%	67.5%	67.5%
	%Molt Group 2	30.1%	30.1%	25.7%	25.7%	25.7%	25.7%	25.7%
	%Molt Group 3+	6.8%	6.8%	5.9%	5.9%	5.9%	5.9%	5.9%
	% > Size at 50% maturity	28.1%	28.1%	28.1%	28.1%	28.1%	28.1%	28.1%
5	# Molt Group 1	22,838	25,932	31,517	66,005	71,874	123,209	56,118
	# Molt Group 2	63,098	71,643	81,516	170,719	185,897	318,672	145,145
	# Molt Group 3+	37,508	42,589	44,230	92,632	100,867	172,910	78,756
	> Size at 50% maturity	95,104	107,985	121,900	255,296	277,993	476,546	217,053
	% Molt Group 1	19.1%	19.1%	20.5%	20.5%	20.5%	20.5%	20.5%
	%Molt Group 2	52.6%	52.6%	53.1%	53.1%	53.1%	53.1%	53.1%
	%Molt Group 3+	31.3%	31.3%	28.8%	28.8%	28.8%	28.8%	28.8%
	% > Size at 50% maturity	79.3%	79.3%	79.3%	79.3%	79.3%	79.3%	79.3%
6	# Molt Group 1	12,295	22,000	37,465	57,962	62,982	124,927	79,572
	# Molt Group 2	19,109	34,193	60,080	92,947	100,998	200,334	127,602
	# Molt Group 3+	28,220	50,494	80,556	124,626	135,421	268,612	171,091
	> Size at 50% maturity	45,256	80,976	137,485	212,699	231,124	458,442	292,002
	% Molt Group 1	20.6%	20.6%	20.7%	20.7%	20.7%	20.7%	20.7%
	%Molt Group 2	32.0%	32.0%	33.1%	33.1%	33.1%	33.1%	33.1%
	%Molt Group 3+	47.3%	47.3%	44.4%	44.4%	44.4%	44.4%	44.4%
	% > Size at 50% maturity	75.8%	75.8%	75.8%	75.8%	75.8%	75.8%	75.8%
7	# Molt Group 1	274,708	238,513	223,365	283,998	300,871	404,671	508,309
	# Molt Group 2	52,485	45,570	41,373	52,604	55,730	74,956	94,153
	# Molt Group 3+	23,396	20,314	20,474	26,032	27,580	37,096	46,594
	> Size at 50% maturity	57,994	50,354	54,317	69,062	73,167	98,409	123,611
	% Molt Group 1	83.0%	83.0%	72.1%	72.1%	72.1%	72.1%	72.1%
	%Molt Group 2	15.9%	15.9%	13.4%	13.4%	13.4%	13.4%	13.4%
	%Molt Group 3+	7.1%	7.1%	6.6%	6.6%	6.6%	6.6%	6.6%
	% > Size at 50% maturity	17.5%	17.5%	17.5%	17.5%	17.5%	17.5%	17.5%

Table 4.2.2 Number and % in molt groups 1,2,3+ and > than size at 50% maturity, by Grid Group - FEMALES

	Females								
		Molt1	Molt2	Molt3	>50% Maturity	% Molt 1	% Molt 2	% Molt 3	% >50% Maturity
1	1998-99	2164068	247794	1271	139781	90%	10%	0%	6%
	1999-00	2057824	237536	1231	132922	90%	10%	0%	6%
	2000-01	1730730	271207	20222	228385	86%	13%	1%	11%
	2001-02	2162809	227523	2677	161943	90%	10%	0%	7%
	2002-03	1806169	189356	0	132711	91%	9%	0%	7%
	2003-04	1741221	182064	1222	140519	90%	9%	0%	7%
	2004-05	2154070	202590	5513	157111	91%	9%	0%	7%
2a	1998-99	4154924	313579	21559	243024	93%	7%	0%	5%
	1999-00	4432952	236598	4355	158216	95%	5%	0%	3%
	2000-01	4076333	318108	6817	234037	93%	7%	0%	5%
	2001-02	3765837	196265	3067	153332	95%	5%	0%	4%
	2002-03	2950089	226402	17152	188668	92%	7%	1%	6%
	2003-04	2639003	210737	14368	162842	92%	7%	1%	6%
	2004-05	2631718	152880	10920	118560	94%	5%	0%	4%
2b	1998-99	1335263	234442	19390	194781	84%	15%	1%	12%
	1999-00	1511443	205618	14166	155394	87%	12%	1%	9%
	2000-01	1754572	429583	27401	400414	79%	19%	1%	18%
	2001-02	1866866	485537	32990	455086	78%	20%	1%	19%
	2002-03	2143308	345997	22157	293160	85%	14%	1%	12%
	2003-04	2103317	313888	14309	250395	87%	13%	1%	10%
	2004-05	2259558	351096	17610	290562	86%	13%	1%	11%
3	1998-99	201040	104768	19113	105476	62%	32%	6%	32%
	1999-00	144409	94951	15164	91685	57%	37%	6%	36%
	2000-01	334072	141981	8909	129731	69%	29%	2%	27%
	2001-02	542451	112077	4203	90782	82%	17%	1%	14%
	2002-03	432425	92152	3456	75565	82%	17%	1%	14%
	2003-04	594967	119509	4299	97155	83%	17%	1%	14%
	2004-05	618596	126963	4679	103255	82%	17%	1%	14%
4a	1998-99	499919	109915	8577	94793	81%	18%	1%	15%
	1999-00	936439	170296	12406	137966	84%	15%	1%	12%
	2000-01	1426388	183711	7873	146969	88%	11%	0%	9%
	2001-02	1816634	204654	9303	160799	89%	10%	0%	8%
	2002-03	1986505	194636	23113	165441	90%	9%	1%	8%
	2003-04	2259605	218777	39184	192654	90%	9%	2%	8%
	2004-05	1707788	167604	30474	147289	90%	9%	2%	8%
4b	1998-99	62940	26829	2700	20754	68%	29%	3%	22%
	1999-00	54296	23145	2329	17905	68%	29%	3%	22%
	2000-01	152026	47180	5991	46057	74%	23%	3%	22%
	2001-02	211412	65611	8331	64048	74%	23%	3%	22%
	2002-03	305753	94889	12050	92630	74%	23%	3%	22%
	2003-04	384532	119337	15154	116496	74%	23%	3%	22%
	2004-05	204072	63333	8042	61824	74%	23%	3%	22%
5	1998-99	18338	48678	12669	57013	23%	61%	16%	72%
	1999-00	20821	55270	14386	64734	23%	61%	16%	72%
	2000-01	25855	62820	13248	73076	25%	62%	13%	72%
	2001-02	54147	131563	27745	153043	25%	62%	13%	72%
	2002-03	58961	143260	30211	166649	25%	62%	13%	72%
	2003-04	101073	245582	51789	285677	25%	62%	13%	72%
	2004-05	46036	111855	23589	130117	25%	62%	13%	72%

6	1998-99	9110	12962	6667	18073	32%	45%	23%	63%
	1999-00	16301	23193	11927	32337	32%	45%	23%	63%
	2000-01	28127	39378	18226	54904	33%	46%	21%	64%
	2001-02	43515	60921	28197	84940	33%	46%	21%	64%
	2002-03	47284	66197	30640	92299	33%	46%	21%	64%
	2003-04	93789	131305	60775	183076	33%	46%	21%	64%
	2004-05	59739	83634	38710	116609	33%	46%	21%	64%
7	1998-99	116261	17706	4245	15899	84%	13%	3%	12%
	1999-00	100943	15373	3686	13804	84%	13%	3%	12%
	2000-01	105929	12945	3469	14891	87%	11%	3%	12%
	2001-02	134684	16459	4411	18933	87%	11%	3%	12%
	2002-03	142686	17437	4673	20059	87%	11%	3%	12%
	2003-04	191912	23452	6285	26978	87%	11%	3%	12%
	2004-05	241062	29459	7894	33887	87%	11%	3%	12%

Table 4.2.3 Number and % in molt groups 1,2,3+ and > than size at 50% maturity, by Grid Group - MALES

	Males								
		Molt1	Molt2	Molt3	>50% Maturity	% Molt1	% Molt2	% Molt3	% >50% Maturity
1	1998-99	1847654	308790	82598	299894	83%	14%	4%	13%
	1999-00	1746442	295381	73846	281844	83%	14%	3%	13%
	2000-01	1954357	496024	141551	562636	75%	19%	5%	22%
	2001-02	1960715	496536	171312	579515	75%	19%	7%	22%
	2002-03	2095868	492003	144040	563214	77%	18%	5%	21%
	2003-04	1880519	452107	149073	503426	76%	18%	6%	20%
	2004-05	1831580	452038	168136	549888	75%	18%	7%	22%
2a	1998-99	5362204	717313	307700	785908	84%	11%	5%	12%
	1999-00	4871312	564643	219180	582061	86%	10%	4%	10%
	2000-01	5187440	1015675	213587	1061119	81%	16%	3%	17%
	2001-02	6032086	1070258	303598	1146924	81%	14%	4%	15%
	2002-03	4579499	854154	442513	1118289	78%	15%	8%	19%
	2003-04	4104584	850133	356816	1046501	77%	16%	7%	20%
	2004-05	3934317	652080	276120	808080	81%	13%	6%	17%
2b	1998-99	1033396	268815	94306	297019	74%	19%	7%	21%
	1999-00	1180480	261423	73834	259706	78%	17%	5%	17%
	2000-01	1149090	420744	105186	458752	69%	25%	6%	27%
	2001-02	1225685	446627	117579	496534	68%	25%	7%	28%
	2002-03	1533126	380938	92038	395425	76%	19%	5%	20%
	2003-04	1467493	336245	81379	345187	78%	18%	4%	18%
	2004-05	1562871	428138	122168	467760	74%	20%	6%	22%
3	1998-99	94857	43181	47429	81408	51%	23%	26%	44%
	1999-00	65556	36861	45726	76521	44%	25%	31%	52%
	2000-01	146157	113565	78229	177337	43%	34%	23%	52%
	2001-02	296163	141497	47633	162232	61%	29%	10%	33%
	2002-03	237062	114039	40087	133161	61%	29%	10%	34%
	2003-04	338753	159919	53020	184566	61%	29%	10%	33%
	2004-05	356871	167205	57398	194032	61%	29%	10%	33%
4a	1998-99	299952	103821	37015	108786	68%	24%	8%	25%
	1999-00	562014	193979	67667	202249	68%	24%	8%	25%
	2000-01	1190188	262445	91856	313622	77%	17%	6%	20%
	2001-02	1581415	322927	103656	372097	79%	16%	5%	19%
	2002-03	1428143	278573	103401	339397	79%	15%	6%	19%
	2003-04	1554295	262859	93062	311839	81%	14%	5%	16%
	2004-05	1163074	200618	71105	237440	81%	14%	5%	17%
4b	1998-99	25311	15187	6750	18561	54%	32%	14%	39%
	1999-00	21835	13101	5823	16012	54%	32%	14%	39%
	2000-01	60286	32577	12356	41189	57%	31%	12%	39%
	2001-02	83836	45303	17184	57279	57%	31%	12%	39%
	2002-03	121247	65519	24852	82840	57%	31%	12%	39%
	2003-04	152487	82400	31255	104184	57%	31%	12%	39%
	2004-05	80925	43730	16587	55290	57%	31%	12%	39%
5	1998-99	4168	11169	24838	34840	10%	28%	62%	87%
	1999-00	4732	12682	28203	39560	10%	28%	62%	87%
	2000-01	5983	14530	30983	44657	12%	28%	60%	87%
	2001-02	12530	30430	64887	93527	12%	28%	60%	87%
	2002-03	13644	33135	70656	101842	12%	28%	60%	87%
	2003-04	23389	56801	121121	174581	12%	28%	60%	87%
	2004-05	10653	25871	55167	79517	12%	28%	60%	87%

6	1998-99	3259	6148	21554	27183	11%	20%	70%	88%
	1999-00	5832	11000	38566	48639	11%	20%	70%	88%
	2000-01	10351	20702	62330	82581	11%	22%	67%	88%
	2001-02	16013	32027	96429	127759	11%	22%	67%	88%
	2002-03	17400	34801	104781	138825	11%	22%	67%	88%
	2003-04	34515	69029	207837	275365	11%	22%	67%	88%
	2004-05	21984	43968	132381	175392	11%	22%	67%	88%
7	1998-99	138664	34779	19151	42096	72%	18%	10%	22%
	1999-00	120394	30197	16628	36550	72%	18%	10%	22%
	2000-01	126235	28428	17005	39426	74%	17%	10%	23%
	2001-02	160502	36145	21622	50129	74%	17%	10%	23%
	2002-03	170038	38293	22908	53109	74%	17%	10%	23%
	2003-04	228700	51504	30811	71431	74%	17%	10%	23%
	2004-05	287272	64694	38700	89724	74%	17%	10%	23%

Table 4.2.4 A-C Number and % in molt groups 1,2,3+ and > than size at 50% maturity for LFA34 (A – Total, B – Female, C – Male)

A

	# Molt Group 1	#Molt Group 2	# Molt Group 3+	# > Size at 50% maturity
1998-99	16,781,765	2,629,123	737,529	2,588,539
1999-00	17,042,984	2,484,936	649,121	2,351,794
2000-01	19,089,449	3,915,787	865,23	4,113,947
2001-02	21,513,181	4,131,083	1,064,819	4,437,629
2002-03	19,363,435	3,671,282	1,188,727	4,162,784
2003-04	19,353,586	3,901,935	1,331,756	4,489,161
2004-05	18,675,059	3,375,173	1,085,192	3,823,756
	% Molt Group 1	**%Molt Group 2**	**%Molt Group 3+**	**% > Size at 50% maturity**
1998-99	83.3%	13.0%	3.7%	12.8%
1999-00	84.5%	12.3%	3.2%	11.7%
2000-01	80.0%	16.4%	3.6%	17.2%
2001-02	80.5%	15.5%	4.0%	16.6%
2002-03	79.9%	15.2%	4.9%	17.2%
2003-04	78.7%	15.9%	5.4%	18.3%
2004-05	80.7%	14.6%	4.7%	16.5%

B

Females	# Molt Group 1	#Molt Group 2	# Molt Group 3+	# > Size at 50% maturity	% Molt Group 1	%Molt Group 2	%Molt Group 3+	% > Size at 50% maturity
1998-99	8561862	1116672	96190	889593	88%	11%	1%	9%
1999-00	9275428	1061979	79649	804962	89%	10%	1%	8%
2000-01	9634032	1506914	112155	1328463	86%	13%	1%	12%
2001-02	10598354	1500609	120922	1342907	87%	12%	1%	11%
2002-03	9873179	1370327	143452	1227182	87%	12%	1%	11%
2003-04	10109420	1564652	207385	1455793	85%	13%	2%	12%
2004-05	9922639	1289414	147430	1159214	87%	11%	1%	10%

C

Males	# Molt Group 1	#Molt Group 2	# Molt Group 3+	# > Size at 50% maturity	% Molt Group 1	%Molt Group 2	%Molt Group 3+	% > Size at 50% maturity
1998-99	8809464	1509201	641339	1695695	80%	14%	6%	15%
1999-00	8578595	1419266	569472	1543141	81%	13%	5%	15%
2000-01	9830086	2404708	753082	2781318	76%	19%	6%	21%
2001-02	11368945	2621749	943898	3085996	76%	18%	6%	21%
2002-03	10196026	2291453	1045275	2926101	75%	17%	8%	22%
2003-04	9784734	2320995	1124372	3017080	74%	18%	8%	23%
2004-05	9249545	2078341	937762	2657123	75%	17%	8%	22%

Table 4.3.1 Sample output of the length based Cohort Analysis

LFA34 females, 1998-99 fishing season

LENGTH-BASED COHORT ANALYSIS

	(INPUT)	
Terminal F =	0.2	29/01/2006
Natural Mortality (m)=	0.1	
Tc =	0.45	

Length (mm)			(INPUT) Catch (numbers)	(INPUT) Delta-t (y)	Stock Numbers	Mean Number	F/Z	Z	F	F*C
171	#	180	148	2.119	222					
161	#	170	390	2.096	703	904	0.812	0.531	0.431	168
151	#	160	674	2.055	1602	2256	0.749	0.399	0.299	201
141	#	150	1130	2.055	3207	4749	0.704	0.338	0.238	269
131	#	140	3212	2.055	7461	10425	0.755	0.408	0.308	990
121	#	130	8756	1.983	18671	24534	0.781	0.457	0.357	3125
116	-	120	24447	0.949	46043	29255	0.893	0.936	0.836	20429
111	-	115	45660	0.889	97848	61461	0.881	0.843	0.743	33921
106	-	110	136917	0.824	248336	135707	0.910	1.109	1.009	138138
101	-	105	312220	0.769	591413	308576	0.910	1.112	1.012	315906
96	-	100	491372	0.694	1140840	580540	0.894	0.946	0.846	415900
91	-	95	1925722	0.601	3190107	1235454	0.940	1.659	1.559	3001652
86	-	90	2970426	0.523	6402670	2421369	0.925	1.327	1.227	3643986
81	-	85	3853339	0.472	10648309	3923000	0.908	1.082	0.982	3784915
Total			9,774,412		22,397,432	8,738,229	Wtd.Ave.F =		1.162	11359599
							A=		0.687	

LFA34 females, 1999-2000 fishing season

LENGTH-BASED COHORT ANALYSIS

	(INPUT)	
Terminal F =	0.2	29/01/2006
Natural Mortality (m)=	0.1	
Tc =	0.45	

Length (mm)			(INPUT) Catch (numbers)	(INPUT) Delta-t (y)	Stock Numbers	Mean Number	F/Z	Z	F	F*C
171	#	180	265	2.119	398					
161	#	170	587	2.096	1135	1508	0.796	0.489	0.389	228
151	#	160	1,383	2.055	2911	3928	0.779	0.452	0.352	487
141	#	150	1912	2.055	5672	8491	0.692	0.325	0.225	431
131	#	140	3080	2.055	10344	15921	0.659	0.293	0.193	596
121	#	130	7721	1.983	21054	29890	0.721	0.358	0.258	1994
116	-	120	16109	0.949	39962	27989	0.852	0.676	0.576	9272
111	-	115	35475	0.889	80601	51647	0.873	0.787	0.687	24367
106	-	110	114205	0.824	206039	112324	0.910	1.117	1.017	116118
101	-	105	275663	0.769	507889	261874	0.913	1.153	1.053	290179
96	-	100	495255	0.694	1055323	521783	0.905	1.049	0.949	470076
91	-	95	1912443	0.601	3085646	1178802	0.942	1.722	1.622	3102672
86	-	90	3162094	0.523	6488832	2410920	0.929	1.412	1.312	4147313
81	-	85	4190388	0.472	11082924	4037035	0.912	1.138	1.038	4349566
Total			10,216,580		22,588,727	8,662,112	Wtd.Ave.F =		1.225	12513298
							A=		0.706	

Table 4.3.1 cont'd Sample output of the length based Cohort Analysis

LFA34 females,2000-01 fishing season										
									(INPUT)	
LENGTH-BASED COHORT ANALYSIS							Terminal F =		0.2	29/01/2006
							Natural Mortality (m)=		0.1	
								Tc =	0.45	
			(INPUT)	*(INPUT)*						
Length			Catch	Delta-t	Stock	Mean				
(mm)			(numbers)	(y)	Numbers	Number	F/Z	Z	F	F*C
172	#	181	450	2.119	675					
162	#	171	1,194	2.096	2144	2755	0.812	0.533	0.433	517
152	#	161	1,232	2.055	3984	6084	0.669	0.302	0.202	249
142	#	151	3878	2.055	9147	12844	0.751	0.402	0.302	1171
132	#	141	4394	2.055	16053	25120	0.636	0.275	0.175	769
122	#	131	10762	1.983	31341	45249	0.704	0.338	0.238	2560
117	-	121	17822	0.949	53060	38978	0.821	0.557	0.457	8149
112	-	116	47105	0.889	107023	68577	0.873	0.787	0.687	32356
107	-	111	152879	0.824	274863	149612	0.911	1.122	1.022	156218
102	-	106	404578	0.769	715674	362324	0.918	1.217	1.117	451759
97	-	101	683409	0.694	1472149	730667	0.903	1.035	0.935	639208
92	-	96	2379229	0.601	4007901	1565233	0.938	1.620	1.520	3616540
87	-	91	3563823	0.523	7871929	3002048	0.922	1.287	1.187	4230724
82	-	86	4305047	0.472	12650012	4730350	0.901	1.010	0.910	3917984
Total			11,575,803		27,215,956	10,739,840	Wtd.Ave.F =		1.128	13058203
								A=	0.676	

LFA34 females, 2001-02 fishing season										
									(INPUT)	
LENGTH-BASED COHORT ANALYSIS							Terminal F =		0.2	29/01/2006
							Natural Mortality (m)=		0.1	
								Tc =	0.45	
			(INPUT)	*(INPUT)*						
Length			Catch	Delta-t	Stock	Mean				
(mm)			(numbers)	(y)	Numbers	Number	F/Z	Z	F	F*C
172	#	181	3,763	2.119	5644					
162	#	171	1,302	2.096	8391	14452	0.474	0.190	0.090	117
152	#	161	1,044	2.055	11450	20151	0.341	0.152	0.052	54
142	#	151	4277	2.055	18753	30260	0.586	0.241	0.141	604
132	#	141	6581	2.055	30249	49149	0.572	0.234	0.134	881
122	#	131	14141	1.983	52344	79534	0.640	0.278	0.178	2514
117	-	121	17118	0.949	75420	59581	0.742	0.387	0.287	4918
112	-	116	49656	0.889	134117	90412	0.846	0.649	0.549	27271
107	-	111	146520	0.824	297684	170471	0.896	0.959	0.859	125933
102	-	106	414741	0.769	750840	384154	0.915	1.180	1.080	447762
97	-	101	681767	0.694	1508147	755403	0.900	1.003	0.903	615309
92	-	96	2500036	0.601	4170252	1620689	0.939	1.643	1.543	3856497
87	-	91	3926058	0.523	8413866	3175563	0.925	1.336	1.236	4853920
82	-	86	4756740	0.472	13679542	5089359	0.903	1.035	0.935	4445859
Total			12,523,743		29,156,701	11,539,180	Wtd.Ave.F =		1.148	14381642
								A=	0.683	

Table 4.3.1 cont'd Sample output of the length based Cohort Analysis

LFA34 females, 2002-03 fishing season

LENGTH-BASED COHORT ANALYSIS

	(INPUT)	
Terminal F =	0.2	29/01/2006
Natural Mortality (m)=	0.1	
Tc =	0.45	

Length (mm)			(INPUT) Catch (numbers)	(INPUT) Delta-t (y)	Stock Numbers	Mean Number	F/Z	Z	F	F*C
172	#	181	757	2.119	1135					
162	#	171	492	2.096	1941	3134	0.611	0.257	0.157	77
152	#	161	1,135	2.055	3628	5526	0.673	0.305	0.205	233
142	#	151	7081	2.055	12223	15135	0.824	0.568	0.468	3313
132	#	141	11364	2.055	27475	38887	0.745	0.392	0.292	3321
122	#	131	35257	1.983	72048	93158	0.791	0.478	0.378	13343
117	-	121	16992	0.949	96954	79142	0.682	0.315	0.215	3648
112	-	116	50005	0.889	158017	110581	0.819	0.552	0.452	22612
107	-	111	134671	0.824	311340	186517	0.878	0.822	0.722	97237
102	-	106	357040	0.769	705855	374749	0.905	1.053	0.953	340168
97	-	101	610287	0.694	1386185	700433	0.897	0.971	0.871	531743
92	-	96	2332314	0.601	3868407	1499077	0.940	1.656	1.556	3628693
87	-	91	3558023	0.523	7719004	2925733	0.924	1.316	1.216	4326960
82	-	86	4442912	0.472	12630518	4686019	0.905	1.048	0.948	4212417
Total			11,558,330		26,994,729	10,718,090	Wtd.Ave.F =		1.141	13183766
								A=	0.680	

LFA34 females, 2003-04 fishing season

LENGTH-BASED COHORT ANALYSIS

	(INPUT)	
Terminal F =	0.2	29/01/2006
Natural Mortality (m)=	0.1	
Tc =	0.45	

Length (mm)			(INPUT) Catch (numbers)	(INPUT) Delta-t (y)	Stock Numbers	Mean Number	F/Z	Z	F	F*C
172	#	181	1,501	2.119	2251					
162	#	171	904	2.096	3769	6144	0.595	0.247	0.147	133
152	#	161	2251	2.055	7097	10777	0.676	0.309	0.209	470
142	#	151	18014	2.055	28475	33638	0.843	0.636	0.536	9647
132	#	141	13605	2.055	49893	78128	0.635	0.274	0.174	2369
122	#	131	40289	1.983	104883	147016	0.733	0.374	0.274	11041
117	-	121	27596	0.949	144125	116458	0.703	0.337	0.237	6539
112	-	116	78064	0.889	238779	165905	0.825	0.571	0.471	36732
107	-	111	172393	0.824	438182	270098	0.865	0.738	0.638	110032
102	-	106	424427	0.769	912601	499922	0.895	0.949	0.849	360332
97	-	101	671952	0.694	1671400	868469	0.886	0.874	0.774	519902
92	-	96	2397984	0.601	4238773	1693887	0.934	1.516	1.416	3394753
87	-	91	3587975	0.523	8139930	3131821	0.920	1.246	1.146	4110568
82	-	86	4662664	0.472	13296266	4936716	0.904	1.044	0.944	4403825
Total			12,099,618		29,276,425	11,958,981	Wtd.Ave.F =		1.072	12966343
								A=	0.658	

Table 4.3.1 cont'd Sample output of the length based Cohort Analysis

LFA34 females, 2004-05 fishing season										
									(INPUT)	
LENGTH-BASED COHORT ANALYSIS								Terminal F =	0.2	29/01/2006
								Natural Mortality (m)=	0.1	
								Tc =	0.45	
			(INPUT)	(INPUT)						
Length			Catch	Delta-t	Stock	Mean				
(mm)			(numbers)	(y)	Numbers	Number	F/Z	Z	F	F*C
172	#	181	956	2.119	1434					
162	#	171	2,049	2.096	4019	5371	0.792	0.481	0.381	781
152	#	161	1,434	2.055	6509	10557	0.576	0.236	0.136	195
142	#	151	12276	2.055	21459	26738	0.821	0.559	0.459	5637
132	#	141	8362	2.055	35525	57046	0.594	0.247	0.147	1226
122	#	131	28590	1.983	74574	104589	0.732	0.373	0.273	7815
117	-	121	23548	0.949	106574	84517	0.736	0.379	0.279	6561
112	-	116	53682	0.889	172359	121028	0.816	0.544	0.444	23811
107	-	111	127066	0.824	319021	195958	0.866	0.748	0.648	82395
102	-	106	331564	0.769	687776	371917	0.899	0.991	0.891	295588
97	-	101	568062	0.694	1323244	674062	0.894	0.943	0.843	478731
92	-	96	2198012	0.601	3663578	1423219	0.939	1.644	1.544	3394599
87	-	91	3551951	0.523	7496955	2814257	0.927	1.362	1.262	4483015
82	-	86	4638934	0.472	12597965	4620758	0.909	1.104	1.004	4657181
Total			11,546,485		26,510,991	10,510,015	Wtd.Ave.F =		1.164	13437535
								A=	0.688	

Table 4.4.1 Sample sizes of exploited (legal catch) and reference catches (Sub legal catch, 75-80mm) and (new sub legal catches (81-82.5mm). Areas 1 (341, =Grid Group…), Area 2 (342=Grid Group…), Area 3 (343=Grid Group…). First two digits of legal code indicate size (10, MLS – 90mm; 11, 91-100mm; 12, >100mm).

Area	Season	LegalCode	Legal Catch	Sub legal catch	New Sub legal catch
341	19992000	1001	126	191	6
341	20002001	1001	424	679	146
341	20012002	1001	362	800	134
341	20022003	1001	396	560	120
341	20032004	1001	295	366	105
341	20042005	1001	630	1073	247
341	19992000	1002	104	198	2
341	20002001	1002	373	712	169
341	20012002	1002	325	777	163
341	20022003	1002	249	492	135
341	20032004	1002	194	281	79
341	20042005	1002	382	915	176
341	19992000	1101	47	191	6
341	20002001	1101	213	679	146
341	20012002	1101	143	800	134
341	20022003	1101	172	560	120
341	20032004	1101	169	366	105
341	20042005	1101	311	1073	247
341	19992000	1102	21	198	2
341	20002001	1102	118	712	169
341	20012002	1102	88	777	163
341	20022003	1102	93	492	135
341	20032004	1102	82	281	79
341	20042005	1102	120	915	176
341	19992000	1201	7	191	6
341	20002001	1201	56	679	146
341	20012002	1201	24	800	134
341	20022003	1201	45	560	120
341	20032004	1201	54	366	105
341	20042005	1201	77	1073	247
341	19992000	1202	2	198	2
341	20002001	1202	17	712	169
341	20012002	1202	6	777	163
341	20022003	1202	22	492	135
341	20032004	1202	11	281	79
341	20042005	1202	22	915	176
342	19992000	1001	563	902	41
342	20002001	1001	900	1651	267
342	20012002	1001	1035	2550	471
342	20022003	1001	1081	2176	381

Area	Season	LegalCode	Legal Catch	Sub legal catch	New Sub legal catch
342	20032004	1001	740	1135	279
342	20042005	1001	747	1379	265
342	19992000	1002	496	832	27
342	20002001	1002	737	1625	266
342	20012002	1002	843	2695	509
342	20022003	1002	976	2192	342
342	20032004	1002	690	1209	230
342	20042005	1002	648	1426	282
342	19992000	1101	205	902	41
342	20002001	1101	544	1651	267
342	20012002	1101	809	2550	471
342	20022003	1101	580	2176	381
342	20032004	1101	482	1135	279
342	20042005	1101	533	1379	265
342	19992000	1102	155	832	27
342	20002001	1102	388	1625	266
342	20012002	1102	580	2695	509
342	20022003	1102	379	2192	342
342	20032004	1102	408	1209	230
342	20042005	1102	482	1426	282
342	19992000	1201	81	902	41
342	20002001	1201	172	1651	267
342	20012002	1201	231	2550	471
342	20022003	1201	171	2176	381
342	20032004	1201	219	1135	279
342	20042005	1201	299	1379	265
342	19992000	1202	29	832	27
342	20002001	1202	76	1625	266
342	20012002	1202	138	2695	509
342	20022003	1202	45	2192	342
342	20032004	1202	144	1209	230
342	20042005	1202	253	1426	282
343	19992000	1001	20	11	0
343	20002001	1001	49	50	34
343	20012002	1001	91	111	14
343	20022003	1001	267	366	109
343	20032004	1001	313	445	134
343	20042005	1001	203	409	140
343	19992000	1002	18	16	0
343	20002001	1002	38	38	28
343	20012002	1002	84	108	12
343	20022003	1002	299	343	75
343	20032004	1002	376	551	151
343	20042005	1002	203	386	101
343	19992000	1101	0	11	0
343	20002001	1101	9	50	34

Area	Season	LegalCode	Legal Catch	Sub legal catch	New Sub legal catch
343	20012002	1101	49	111	14
343	20022003	1101	118	366	109
343	20032004	1101	191	445	134
343	20042005	1101	98	409	140
343	19992000	1102	1	16	0
343	20002001	1102	19	38	28
343	20012002	1102	50	108	12
343	20022003	1102	134	343	75
343	20032004	1102	207	551	151
343	20042005	1102	86	386	101
343	19992000	1201	0	11	0
343	20002001	1201	6	50	34
343	20012002	1201	61	111	14
343	20022003	1201	46	366	109
343	20032004	1201	108	445	134
343	20042005	1201	31	409	140
343	19992000	1202	0	16	0
343	20002001	1202	8	38	28
343	20012002	1202	24	108	12
343	20022003	1202	34	343	75
343	20032004	1202	99	551	151
343	20042005	1202	19	386	101

Table 4.5.1 Exploitation and Deviance Information Criteria (DIC) estimates from Catch and effort data.

a) LFA 34 log books starting at beginning of season until December 31 the same year in the Lobster Bay area of LFA 34.

	Exponential model		Logit model	
Season	exploitation	DIC	exploitation	DIC
1998-99	0.83	275.1	0.81	385.9
1999-00	0.88	393.5	0.83	499.0
2000-01	0.79	253.1	0.68	463.1
2001-02	0.81	341.3	0.61	379.7
2002-03	0.82	460.7	0.67	374.9
2003-04	0.84	359.1	0.67	434.6
2004-05	0.87	346.5	0.84	316.5

b) Daily catch rate and effort data from Fishermen Scientists Research Society (FSRS) fishing logs for the period starting at the beginning of the lobster fishery every year until December 31st the same year in the Lobster Bay area of LFA 34.

	Exponential model		Logit model		Logit withTemperature	
Season	exploitation	DIC	exploitation	DIC	exploitation	DIC
1999-00	0.55	160.0	0.60	150.7	0.62	152.1
2000-01	0.82	196.6	0.75	200.2	0.98	154.5
2001-02	0.80	216.6	0.75	235.8	0.85	232.6
2002-03	0.94	185.7	0.91	167.7	NA	
2003-04	0.86	204.2	0.75	210.2	NA	
2004-05	0.76	177.1	0.76	186.6	NA	

Table 5.1.1 Anova table for FSRS CPUE (no. per trap haul) of lobsters < 61mm CL, Grid Group 2ab, fall. Cpue is no. of lobsters per trap haul per week. Of a total of 701 records, 223 were removed because there were 0 legal size lobsters recorded.

```
> ANOVA(fsrsmfbgrp.2ab.fall.lt5160.lm1)
Analysis of Variance Table

Response: log(lt5160/Hauls)
                     Df  Sum Sq Mean Sq F value  Pr(>F)
week                  1   0.856   0.856  1.5557 0.21298
factor(Season)        5   5.591   1.118  2.0323 0.07306 .
factor(VesselCode)   43 242.735   5.645 10.2600 < 2e-16 ***
Residuals           428 235.484   0.550
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
>
```

Table 5.1.2 Anova table for FSRS CPUE (no. per trap haul) of lobsters 61-70mm CL, Grid Group 2ab, fall. Cpue is no. of lobsters per trap haul per week. Of a total of 701 records, 95 were removed because there were 0 legal size lobsters recorded.

Shown below the anova are statistics for model coefficients for Season.

```
> ANOVA(fsrsmfbgrp.2ab.fall.s6170.lm1)
Analysis of Variance Table

Response: log(s6170/Hauls)
                     Df  Sum Sq Mean Sq F value    Pr(>F)
week                  1   0.029   0.029  0.0628    0.8022
factor(Season)        5  15.611   3.122  6.7811 3.766e-06 ***
factor(VesselCode)   44 273.944   6.226 13.5223 < 2.2e-16 ***
Residuals           555 255.535   0.460
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
>
> summary(fsrsmfbgrp.2ab.fall.s6170.lm1)

Call:
lm(formula = log(s6170/Hauls) ~ 1 + (week) + factor(Season) +
    factor(VesselCode), data = fsrsmfbgrp.2ab.fall, subset = s6170/Hauls
>
    0)

Residuals:
     Min       1Q   Median       3Q      Max
-2.07473 -0.43213  0.03618  0.44300  1.93872

Coefficients:
                         Estimate Std. Error t value Pr(>|t|)
(Intercept)              -1.30102    0.16339  -7.963 9.56e-15 ***
week                     -0.05019    0.02035  -2.467 0.013936 *
factor(Season)20002001    0.29927    0.10994   2.722 0.006692 **
factor(Season)20012002    0.49826    0.11202   4.448 1.05e-05 ***
factor(Season)20022003    0.53777    0.11787   4.562 6.23e-06 ***
factor(Season)20032004    0.36484    0.11801   3.092 0.002090 **
factor(Season)20042005    0.16035    0.12097   1.326 0.185533
```

Table 5.1.3 Anova table for FSRS CPUE (no. per trap haul) of lobsters 71mm CL to minimum legal size (MLS), Grid Group 2ab, fall. Cpue is no. of lobsters per trap haul per week. Of a total of 701 records, XX were removed because there were 0 legal size lobsters recorded.

Shown below the anova are statistics for model coefficients for Season.

```
Analysis of Variance Table

Response: log(s71mls/Hauls)
                     Df  Sum Sq Mean Sq F value    Pr(>F)
week                  1  19.093  19.093  49.107 6.213e-12 ***
factor(Season)        5  26.255   5.251  13.506 1.552e-12 ***
factor(VesselCode)   44 265.726   6.039  15.533 < 2.2e-16 ***
Residuals           634 246.504   0.389
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

> summary(fsrsmfbgrp.2ab.fall.s71mls.lm1)

Call:
lm(formula = log(s71mls/Hauls) ~ 1 + (week) + factor(Season) +
    factor(VesselCode), data = fsrsmfbgrp.2ab.fall, subset =
s71mls/Hauls > 0)

Residuals:
     Min       1Q   Median       3Q      Max
-2.65984 -0.31447  0.06673  0.37743  2.00124

Coefficients:
                       Estimate Std. Error t value Pr(>|t|)
(Intercept)            0.181797   0.146206   1.243 0.214170
week                  -0.132796   0.017415  -7.625 8.94e-14 ***
factor(Season)20002001 0.057763   0.094552   0.611 0.541479
factor(Season)20012002 0.388858   0.094958   4.095 4.77e-05 ***
factor(Season)20022003 0.340302   0.100416   3.389 0.000745 ***
factor(Season)20032004 0.318587   0.101175   3.149 0.001716 **
factor(Season)20042005 0.104429   0.102870   1.015 0.310420
```

Table 5.1.4 Anova table for FSRS CPUE (no. per trap haul) of lobsters < 61mm CL, Grid Group 2ab, spring. Cpue is no. of lobsters per trap haul per week. Of a total of 1332 records, 388 were removed because there were 0 legal size lobsters recorded.

Shown below the anova are statistics for model coefficients for Season.

```
Analysis of Variance Table

Response: log(lt5160/Hauls)
                     Df Sum Sq Mean Sq F value    Pr(>F)
week2                 1  12.64   12.64 23.2383 1.682e-06 ***
factor(Season)        5  18.44    3.69  6.7788 3.247e-06 ***
factor(VesselCode)   44 370.05    8.41 15.4606 < 2.2e-16 ***
Residuals           893 485.77    0.54
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
>
> summary(fsrsmfbgrp.2ab.sprg.lt5160.lm1)

Call:
lm(formula = log(lt5160/Hauls) ~ 1 + (week2) + factor(Season) +
    factor(VesselCode), data = fsrsmfbgrp.2ab.sprg, subset =
lt5160/Hauls >
    0)

Residuals:
     Min       1Q   Median       3Q      Max
-2.15958 -0.49892  0.02013  0.49390  2.11817

Coefficients:
                           Estimate Std. Error t value Pr(>|t|)
(Intercept)              -1.7779914  0.1778497  -9.997  < 2e-16 ***
week2                     0.0548893  0.0098584   5.568 3.41e-08 ***
factor(Season)20002001 -0.3648547  0.1001156  -3.644 0.000284 ***
factor(Season)20012002 -0.0197813  0.0991398  -0.200 0.841894
factor(Season)20022003 -0.2797820  0.1046721  -2.673 0.007656 **
factor(Season)20032004 -0.0024698  0.1044406  -0.024 0.981139
factor(Season)20042005  0.1938923  0.1053416   1.841 0.066011 .
```

Table 5.1.5 Anova table for FSRS CPUE (no. per trap haul) of lobsters 61-70mm CL to MLS, Grid Group 2ab, spring. Cpue is no. of lobsters per trap haul per week. Of a total of 1332 records, 216 were removed because there were 0 legal size lobsters recorded.

Shown below the anova are statistics for model coefficients for Season.

Analysis of Variance Table

```
Response: log(s6170/Hauls)
                      Df Sum Sq Mean Sq F value    Pr(>F)
week2                  1  27.07   27.07 61.8240 9.171e-15 ***
factor(Season)         5  20.26    4.05  9.2536 1.229e-08 ***
factor(VesselCode)    45 503.76   11.19 25.5690 < 2.2e-16 ***
Residuals           1064 465.84    0.44
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
>
> summary(fsrsmfbgrp.2ab.sprg.s6170.lm1)

Call:
lm(formula = log(s6170/Hauls) ~ 1 + (week2) + factor(Season) +
    factor(VesselCode), data = fsrsmfbgrp.2ab.sprg, subset = s6170/Hauls
>
    0)

Residuals:
     Min       1Q   Median       3Q      Max
-2.44017 -0.39725  0.05536  0.43950  1.94332

Coefficients:
                       Estimate Std. Error t value Pr(>|t|)
(Intercept)           -1.596151   0.129034 -12.370  < 2e-16 ***
week2                  0.078145   0.007951   9.829  < 2e-16 ***
factor(Season)20002001 -0.151543   0.083319  -1.819 0.069220 .
factor(Season)20012002  0.126808   0.083453   1.520 0.128930
factor(Season)20022003 -0.202806   0.085694  -2.367 0.018129 *
factor(Season)20032004 -0.349330   0.086171  -4.054 5.40e-05 ***
factor(Season)20042005 -0.169772   0.088068  -1.928 0.054154 .
```

Table 5.1.6 Anova table for FSRS CPUE (no. per trap haul) of lobsters 71mm CL to MLS, Grid Group 2ab, spring. Cpue is no. of lobsters per trap haul per week. Of a total of 1332 records, 55 were removed because there were 0 legal size lobsters recorded.

Shown below the anova are statistics for model coefficients for Season.

```
Analysis of Variance Table

Response: log(s71mls/Hauls)
                     Df Sum Sq Mean Sq F value    Pr(>F)
week2                 1  85.57   85.57 220.608 < 2.2e-16 ***
factor(Season)        5  65.54   13.11  33.792 < 2.2e-16 ***
factor(VesselCode)   45 538.78   11.97  30.866 < 2.2e-16 ***
Residuals          1226 475.57    0.39
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> summary(fsrsmfbgrp.2ab.sprg.s71mls.lm1)

Call:
lm(formula = log(s71mls/Hauls) ~ 1 + (week2) + factor(Season) +
    factor(VesselCode), data = fsrsmfbgrp.2ab.sprg, subset =
s71mls/Hauls > 0)

Residuals:
     Min       1Q   Median       3Q      Max
-2.90990 -0.33281  0.04812  0.40404  1.63199

Coefficients:
                        Estimate Std. Error t value Pr(>|t|)
(Intercept)            -0.706165   0.105157  -6.715 2.86e-11 ***
week2                   0.110286   0.006931  15.911  < 2e-16 ***
factor(Season)20002001 -0.033507   0.072039  -0.465 0.641925
factor(Season)20012002  0.329816   0.071727   4.598 4.70e-06 ***
factor(Season)20022003  0.153831   0.073394   2.096 0.036291 *
factor(Season)20032004 -0.336135   0.073912  -4.548 5.96e-06 ***
factor(Season)20042005 -0.040669   0.075115  -0.541 0.588313
```

Table 6.1 Indicator Tables

Abundance – Legal sizes: Spatially referenced catch and effort
Unless otherwise indicated, Comparison is between last 5 seasons (2000-01, 2001-02, 2002-03, 2003-04, 2004-05) & "baseline seasons" (2 previous seasons of 1998-99 and 1999-00). "**+**" is higher relative to baseline, "**--**" is lower and "**o**" is no change detectable.

	1	**2a**	**2b**	**3**	**4a**	**4b**	**5**	**6**	**7**	**LFA 34**
Landings										
Fall	+	--	+	+	+	+	+	+	+	+
Winter	--	--	+	+	+	+	+	+	+	+
Spring	--	+	+	+	+	+	+	+	+	+
All Periods	--	--	+	+	+	+	+	+	+	+
Proportion of landings	--	--	o	+	+	+	+	+	+	
Catch rate (LFA 34 log book, raw)										
Fall	+	+	+	+	+	+	+	+	+	
Winter	+	+	+	--	+	+	+	+	+	
Spring	o	o	+	--	+	+	o	o	+	
Catch rate (LFA 34 log book, model)										
Fall	+	+	+	+	+	+	+	+	+	+
Winter	o	o	+	o	+	+	o	o	+	o
Spring	o	o	+	o	o	+	o	o	o	o
Catch rate (FSRS, model)										
Fall		+								
Winter										
Spring		+								
Scallop Survey	--	+			+					

Fishing pressure

Unless otherwise indicated, the comparison is between the last 5 seasons (2000-01, 2001-02, 2002-03, 2003-04,2004-05) & two "baseline seasons" (2 previous seasons of 1998-99 and 1999-00). Here a negative ("--") indicates an increase in effort because it is considered a detrimental effect. A positive ("+") indicates decrease in effort because it is considered a beneficial effect.

	1	**2a**	**2b**	**3**	**4a**	**4b**	**5**	**6**	**7**	**LFA 34**
Fishing effort from LFA 34 log book										
Trap hauls – estimated total	+	+	--	--	--	--	--	--	--	--
Trap hauls – Prop. of TOT	o	+	--	--	--	--	--	--	--	--
Mobility – No. of Grid Fished	***Not relevant***									--
Mobility – No. of Days Fished	***Not relevant***									+
Exploitation rate from CIR										
Extended (81-90, Males)		o								
Strict (MLS-90, Males)		o								
Strict (91-100, Males)		o								
Strict (>100, Males)		o								
Extended (75-90, Females)		+								
Strict (MLS-90, Females)		o								
Strict (91-100, Females)		o								
Strict (>100, Females)		o								
LCA										o
% of catch in first molt group										+
% of mature females in catch										--
Gould-Pollock										
Exponential - LFA 34 log book		o								
Logit - LFA 34 log book		+								
Exponential - FSRS data		--								
Logit - FSRS data		o								

Production – Pre-recruits and spawners

	1	2a	2b	3	4a	4b	5	6	7	LFA 34
Catch rate - FSRS traps, model										
Fall										
<61		o								
61-70		+								
71-MLS		+								
Spring										
<61		o								
61-70		o								
71-MLS		o								
Scallop survey										
<81		--								
Catch rate - At sea-samples										
70-79mm CL	o	o	o	o	o					
Berried females	o	o	o	o	o					

FIGURES

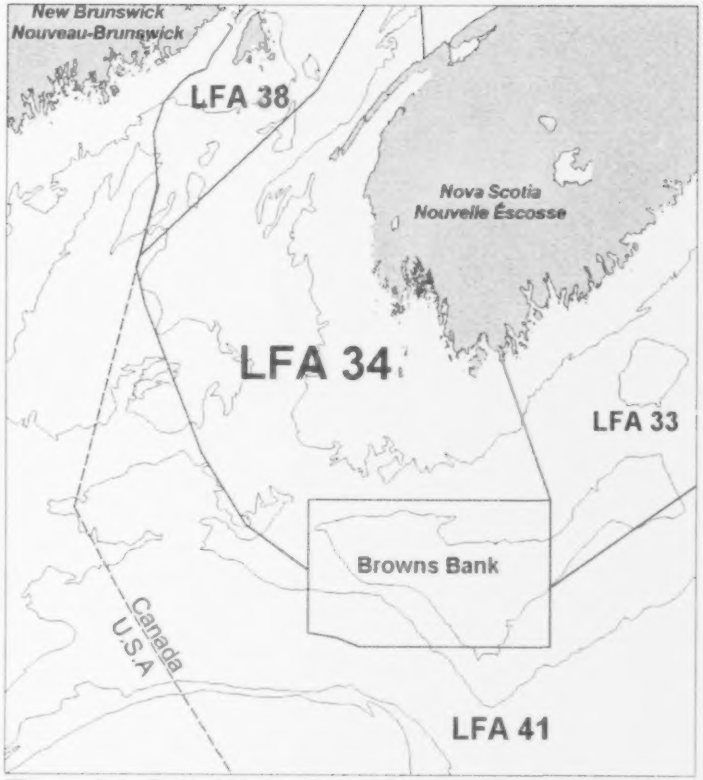


Figure 1.1 Gulf of Maine/Bay of Fundy map showing LFA 34/41

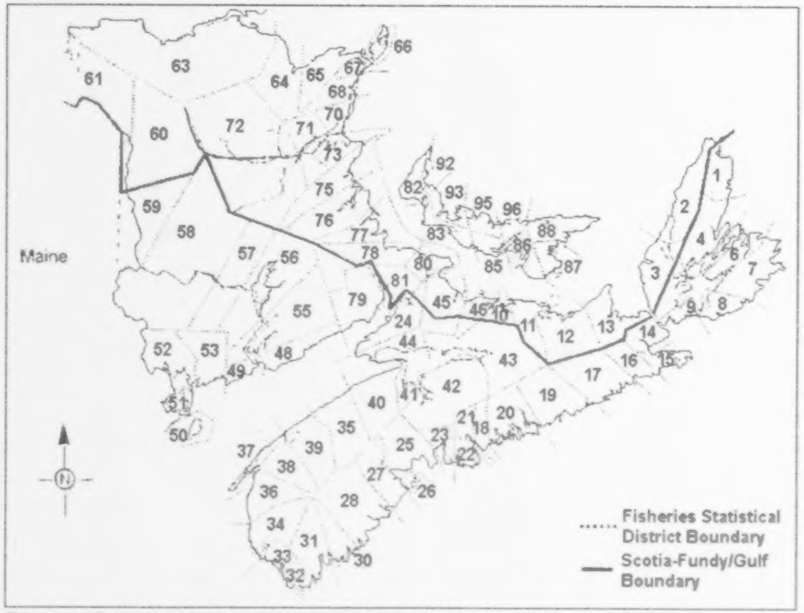


Figure 2.1 Statistical Districts (S.D.)

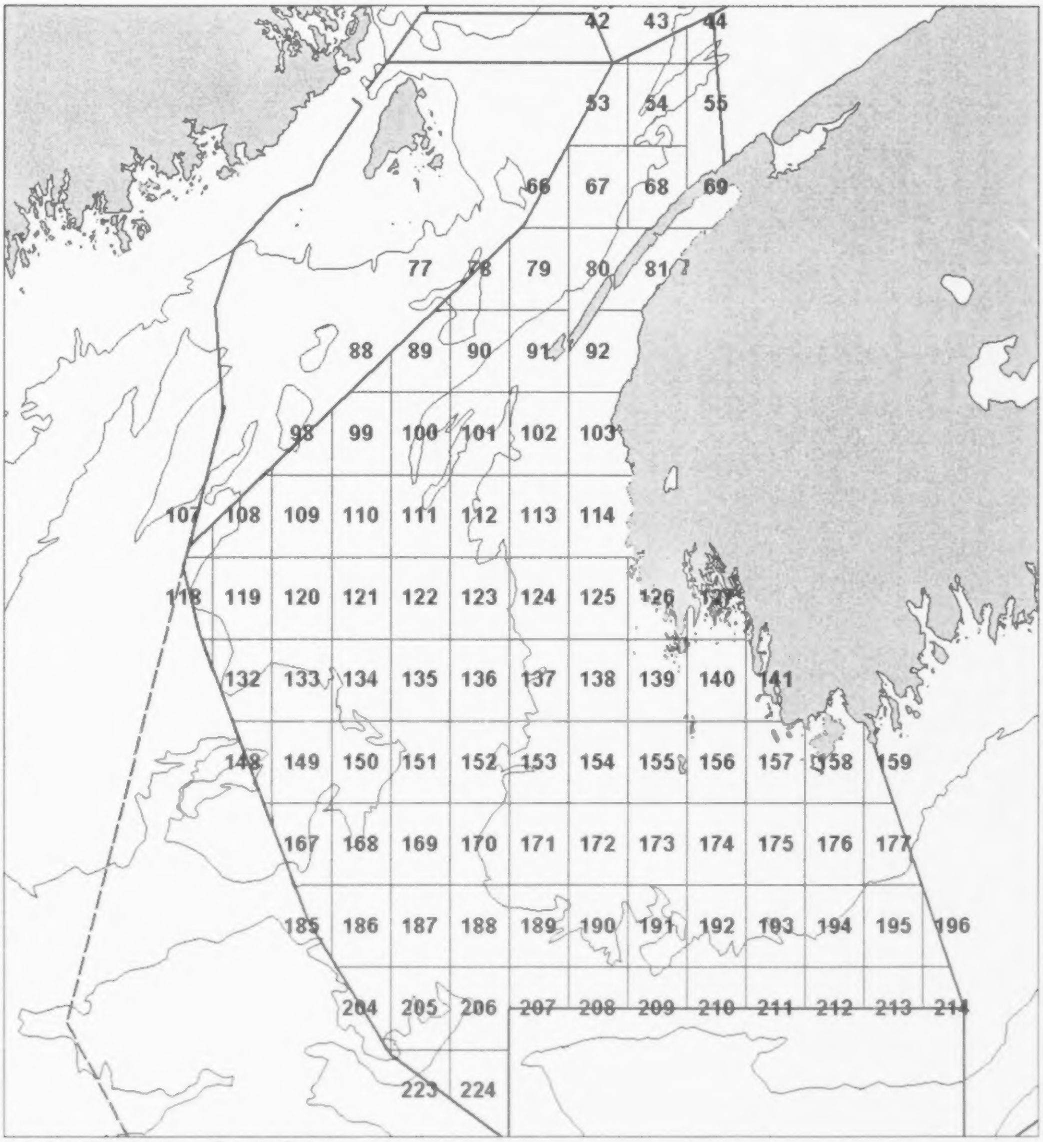


Figure 2.2 LFA 34 Log Book Grids

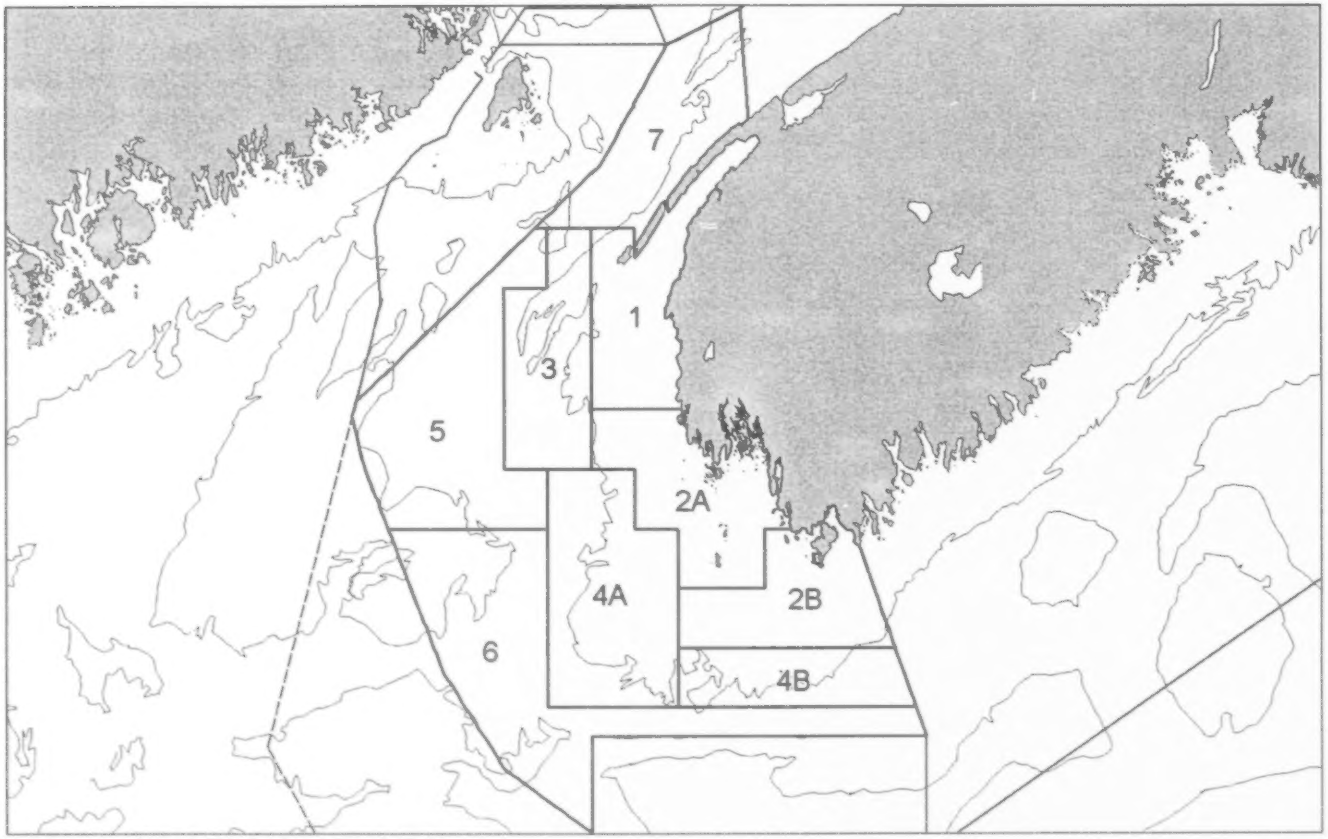


Figure 2.3 Grid Groups from LFA 34 Log Book Grids

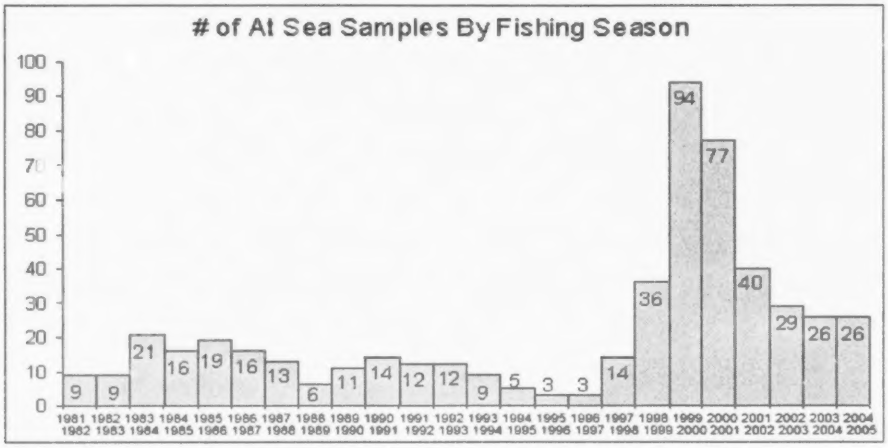
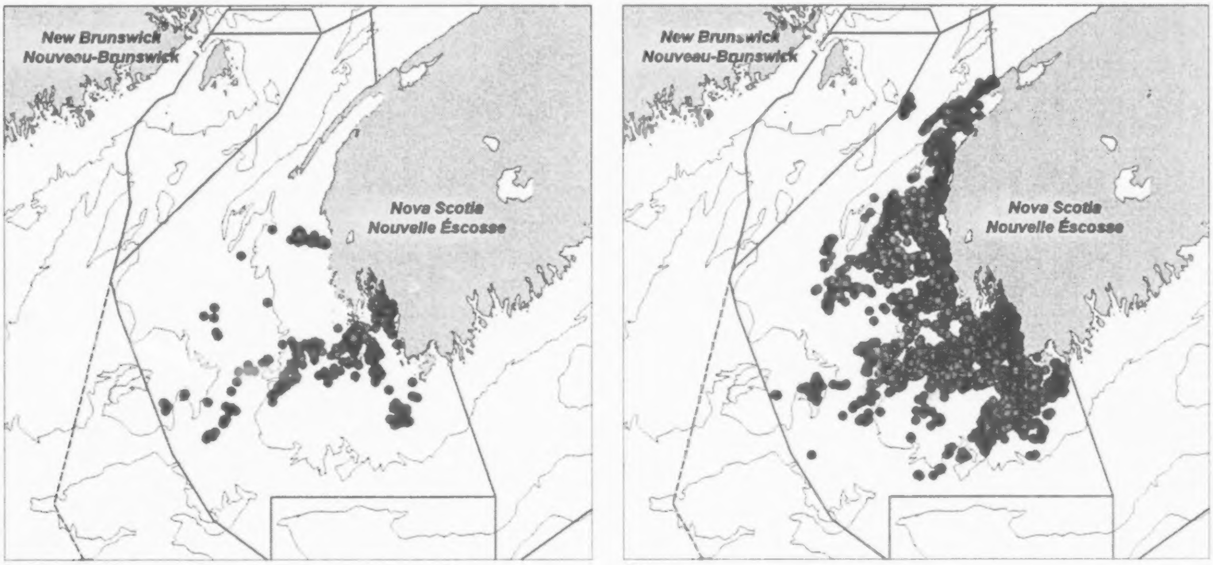


Figure 2.4 Number of at-sea samples per season in LFA 34



A **B**

Figure 2.5 At-sea sample locations **A)** 1988-89 to 1997-98, **B)** 1998-99 to 2004-05

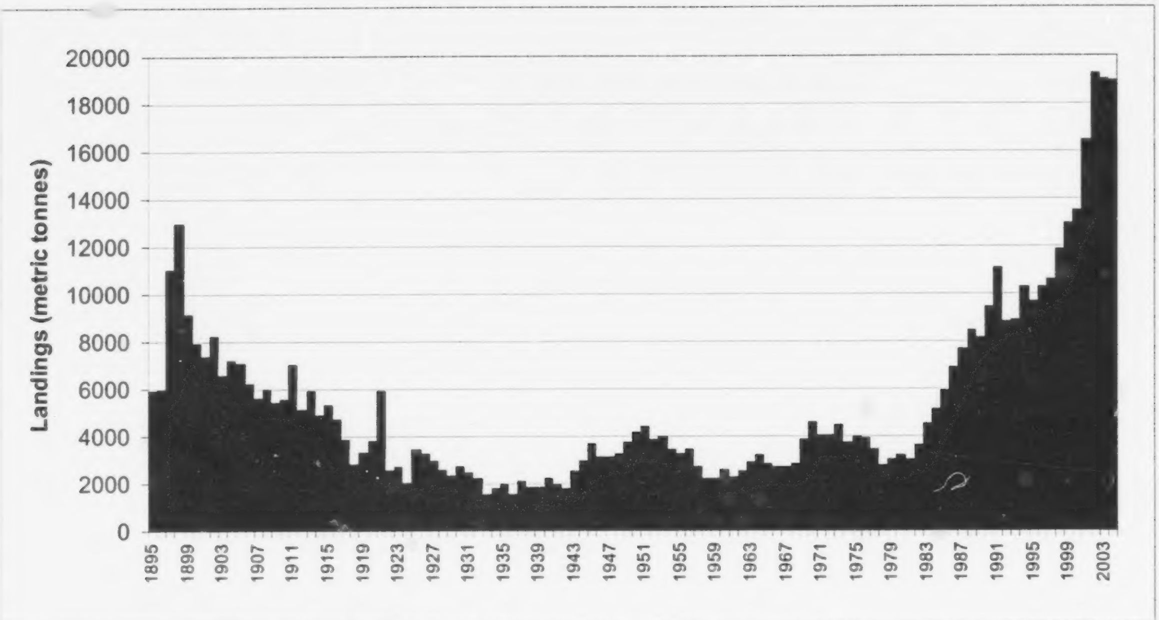


Figure 3.1.1 Lobster Landings LFA 34 (metric tons)

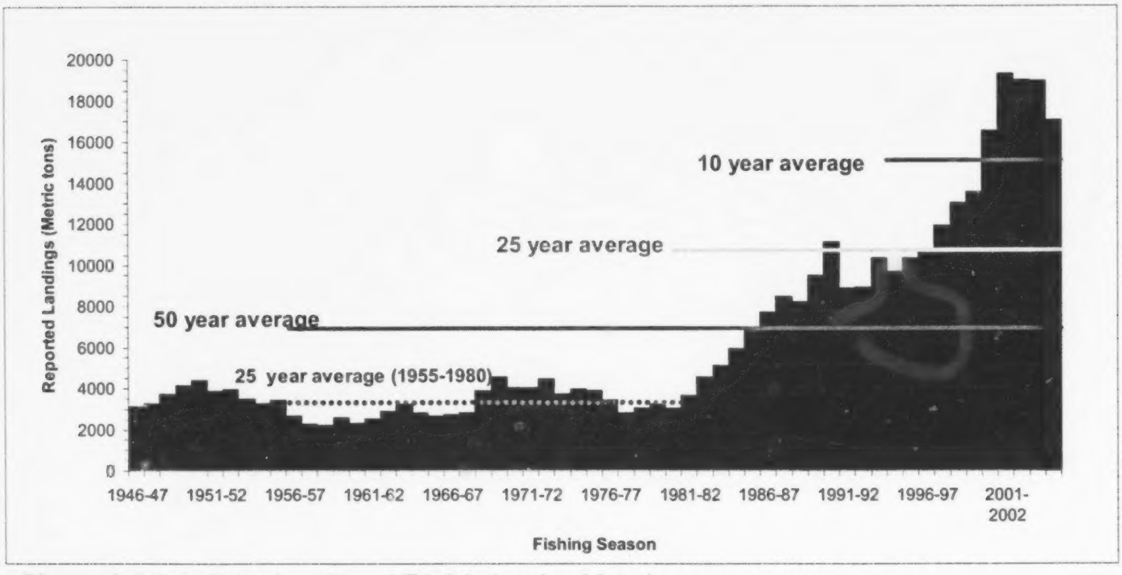
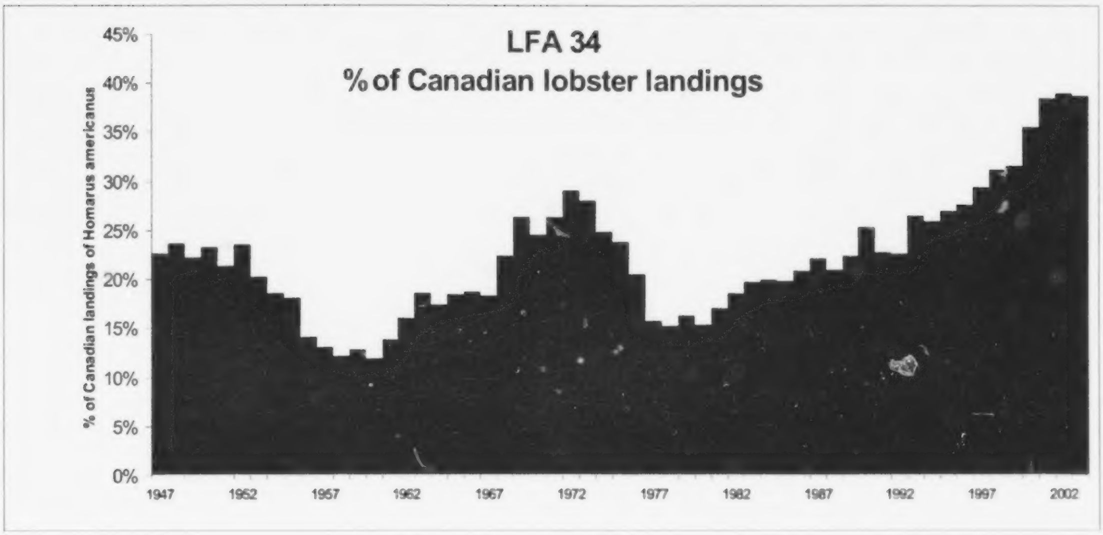


Figure 3.1.2 Lobster Landings LFA 34 showing historic means



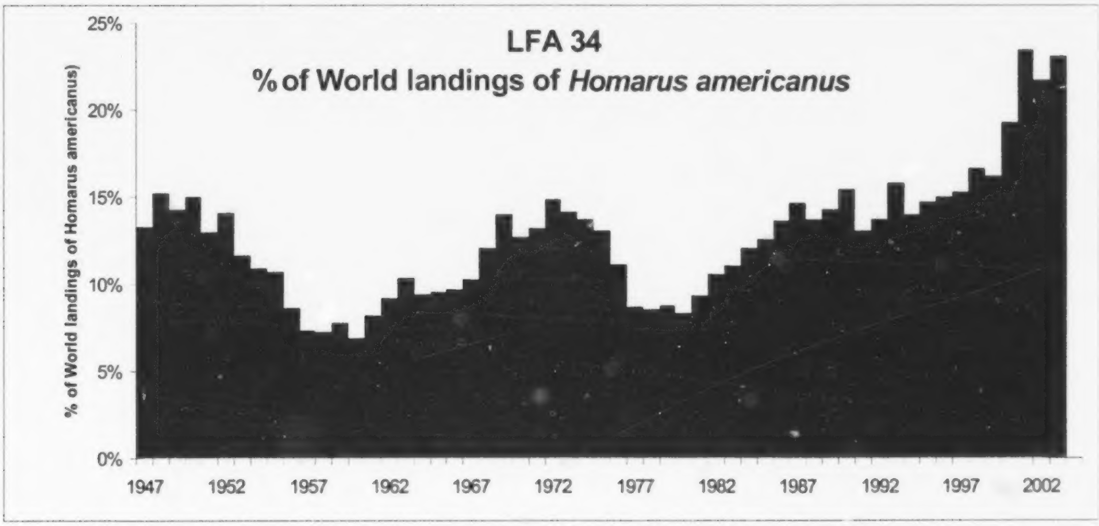


Figure 3.1.3 LFA 34 lobster landings as a percentage of Canadian and world landings of *Homarus americanus*

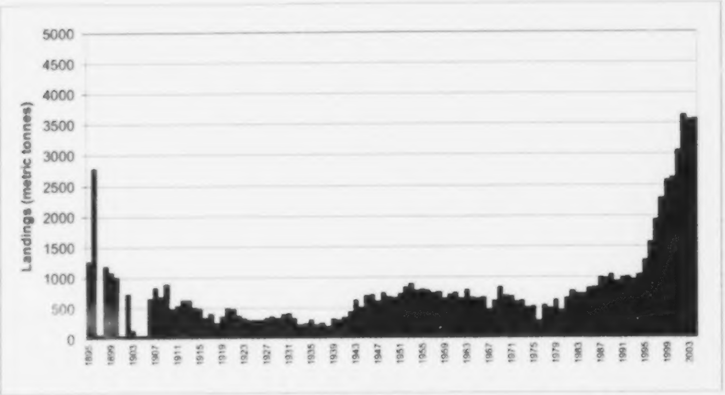


Figure 3.1.4 Bay of Fundy (LFA 35-38) lobster landings

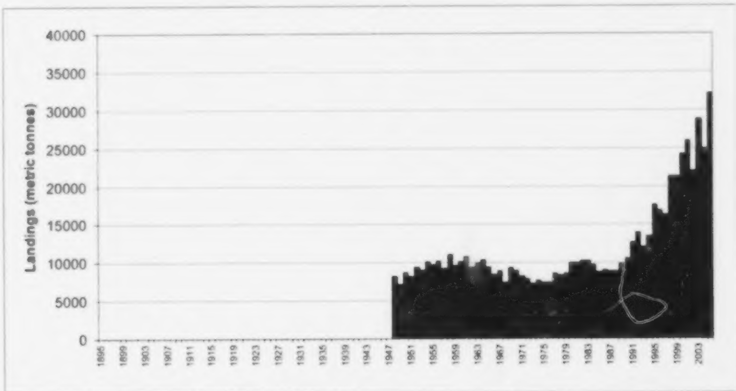


Figure 3.1.5 Maine lobster landings (there has been a change in reporting systems in the last three years so values relative to previous years should be viewed with caution)

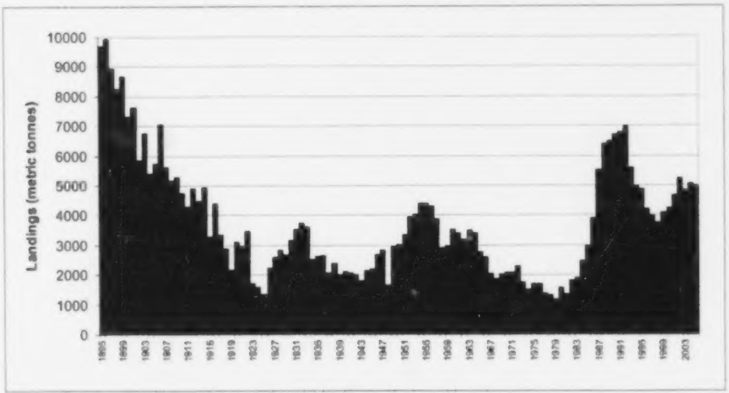
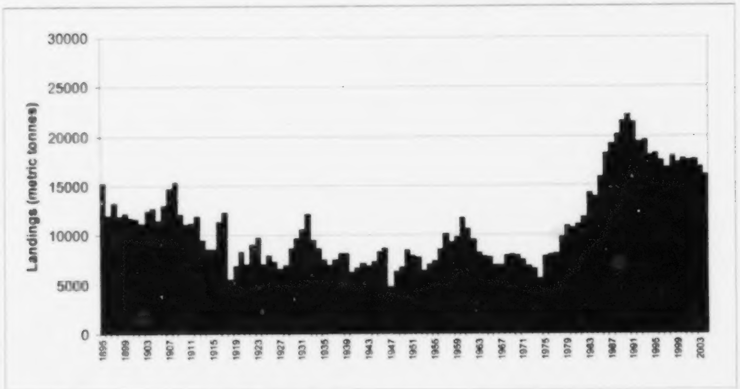
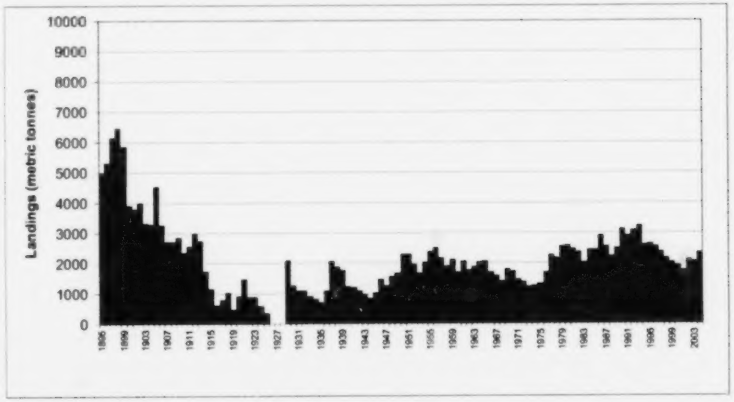


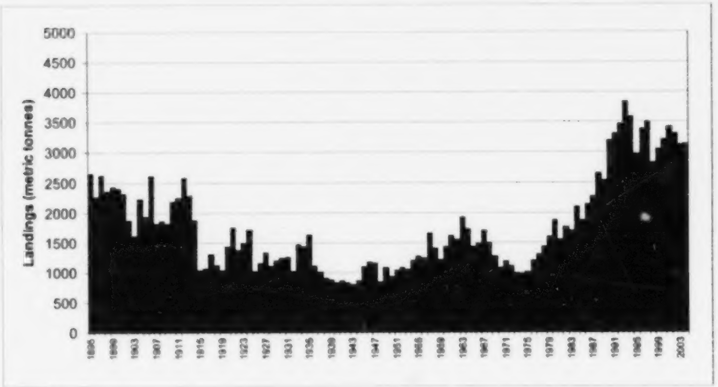
Figure 3.1.6 LFA 31-33 Lobster Landings



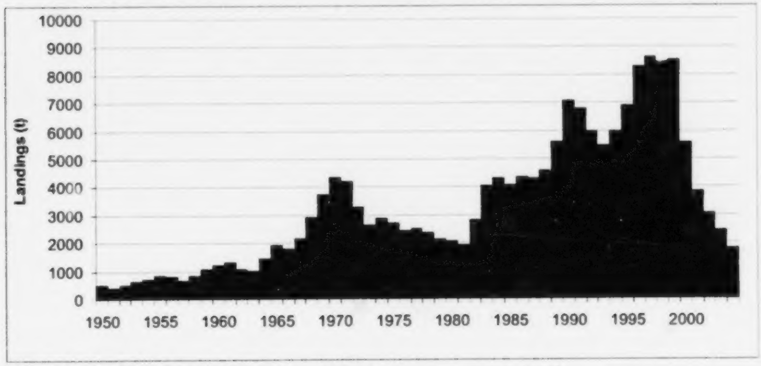
Southern Gulf of St. Lawrence



Newfoundland



Quebec



USA Southern New England (RI, Conn., NY, NJ)

Figure 3.1.7 Lobster landings in other regions

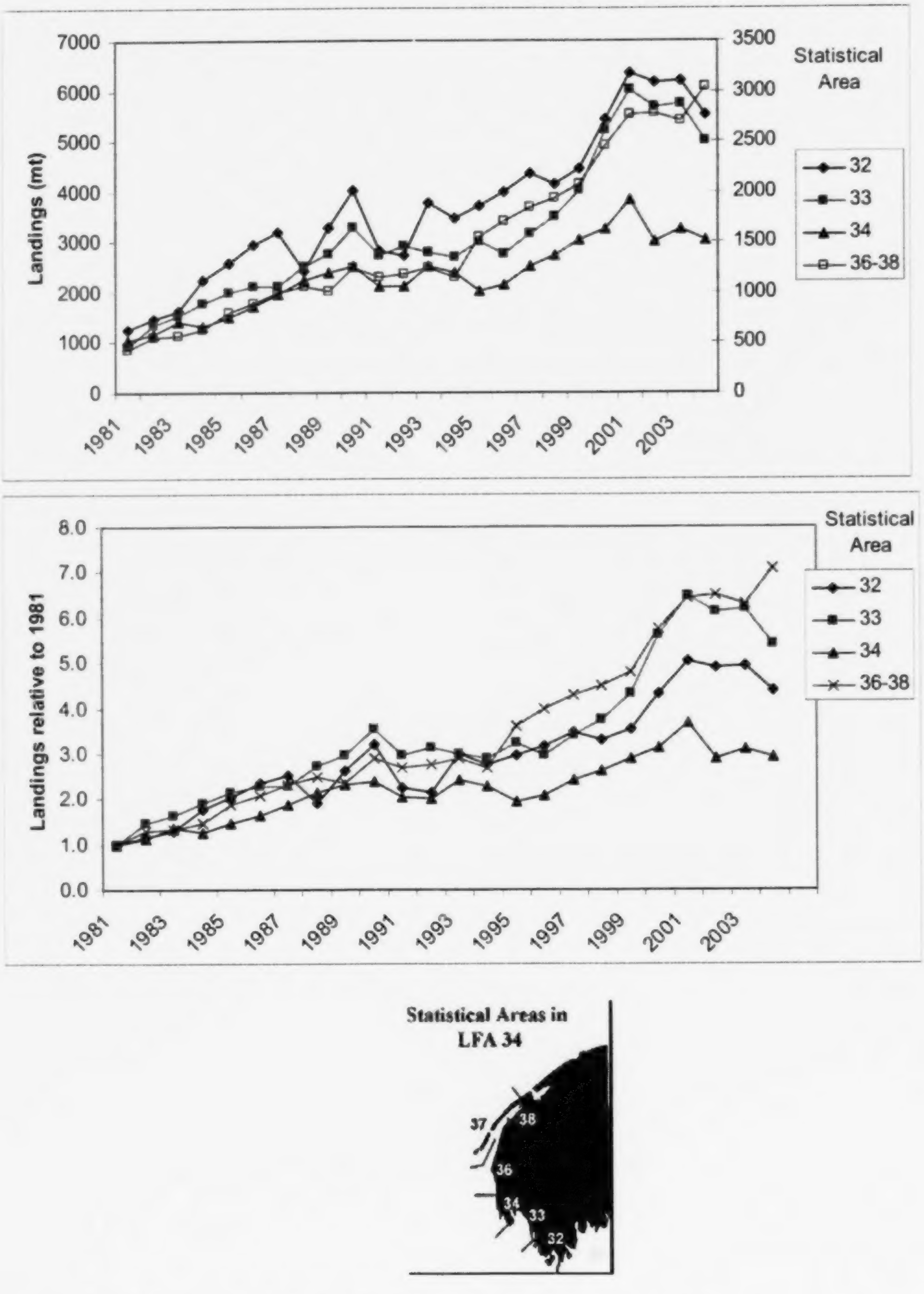


Figure 3.1.8 Landings by Statistical District 1981-82 to 2004-05

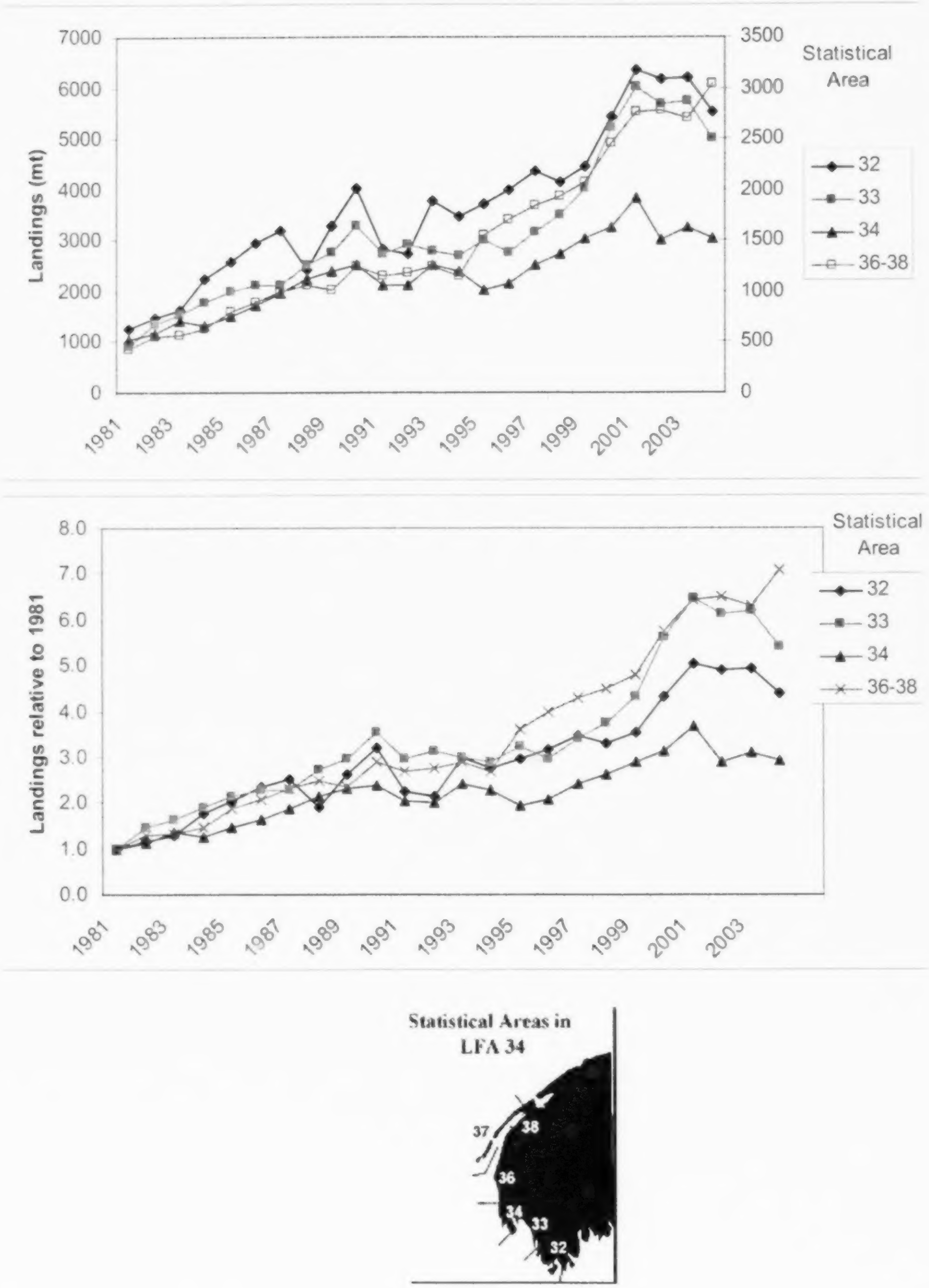


Figure 3.1.8 Landings by Statistical District 1981-82 to 2004-05

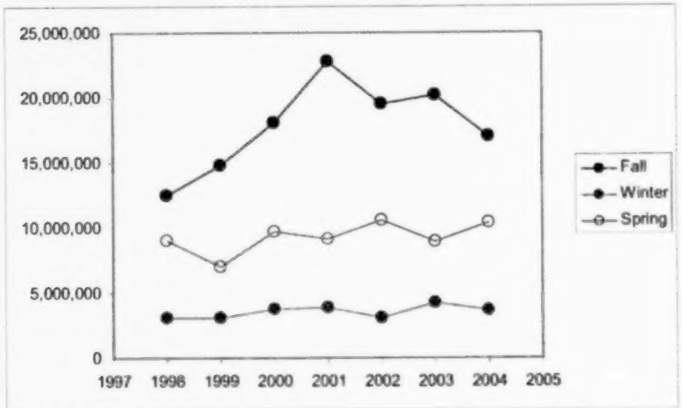
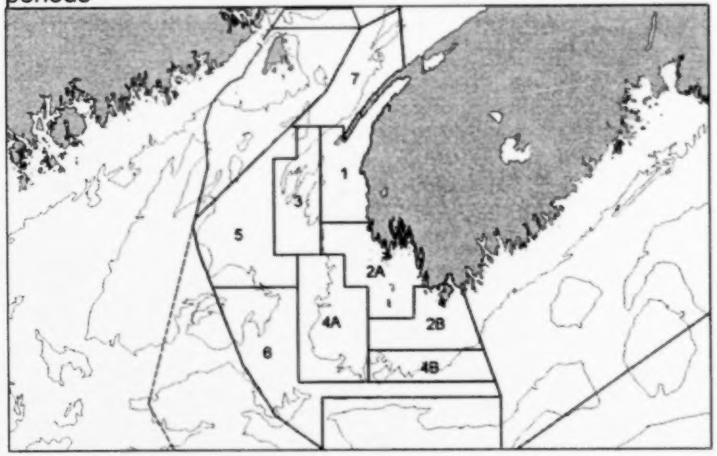


Figure 3.1.9 (a) LFA 34 landings 1998-99 to 2004-0 by time periods



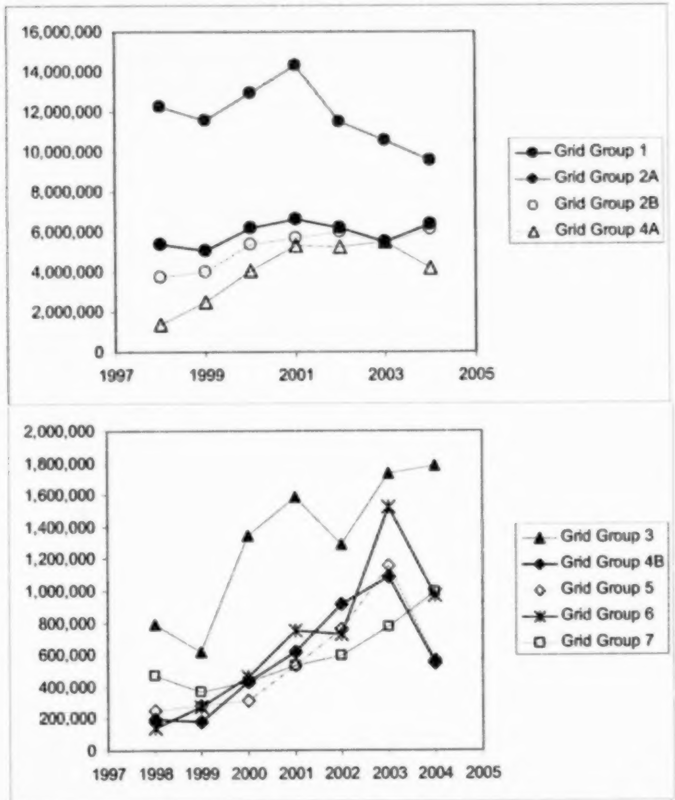
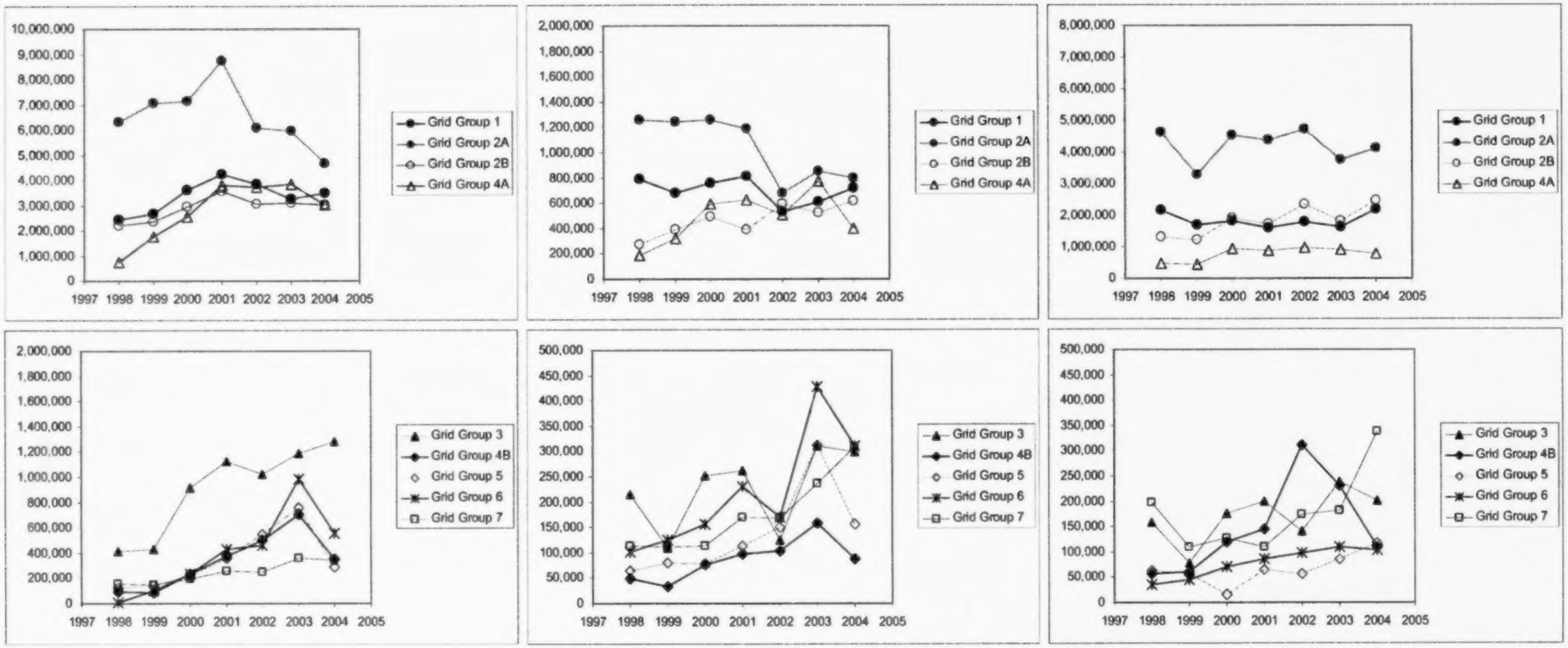


Figure 3.1.9 (b) LFA 34 landings by Grid Groups 1998-99 to 2004-05

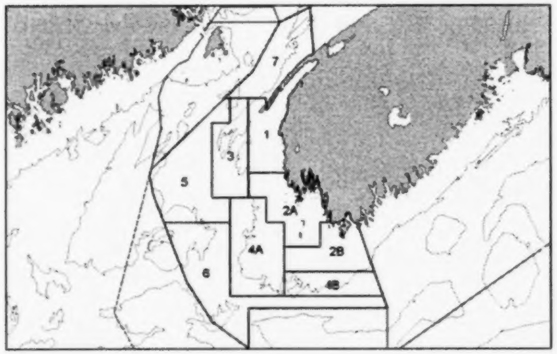


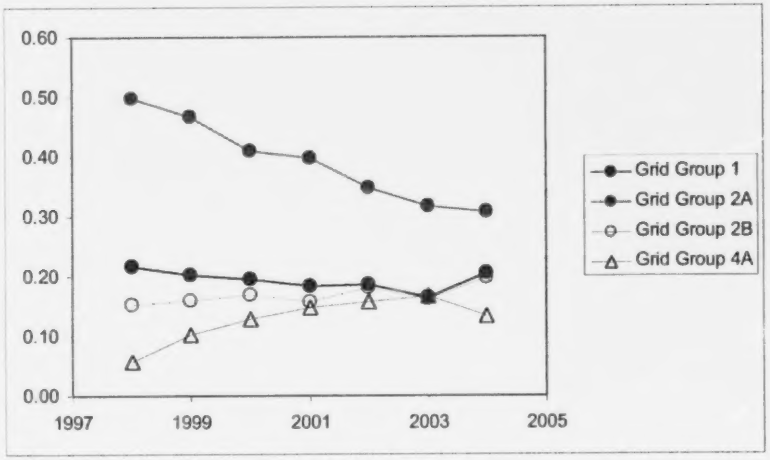
(a) Fall

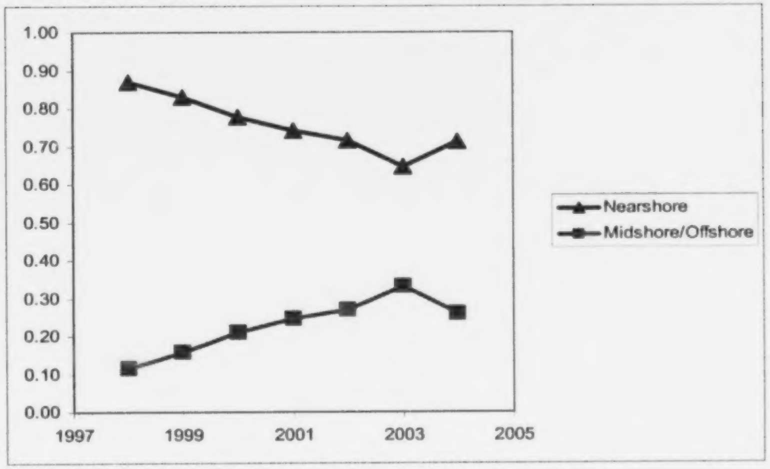
(b) Winter

(c) Spring

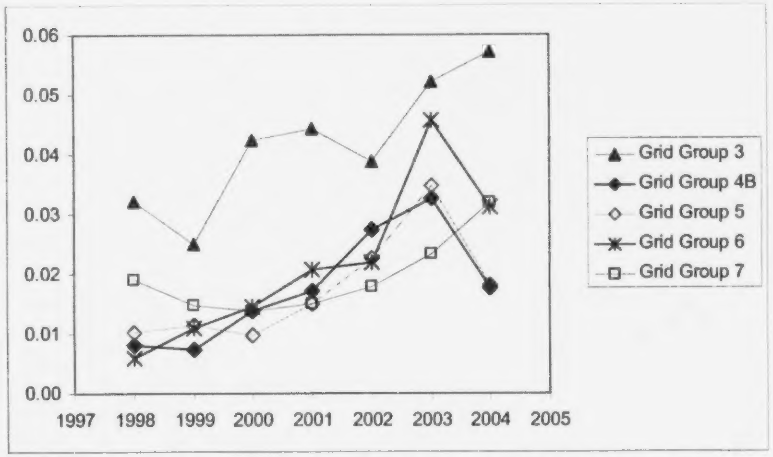
Figure 3.1.10 Landings 1998-99 to 2004-05 by Grid Groups and time periods (Fall, Winter, Spring)







Nearshore (Grid Groups 1,2a, 2b) Midshore/offshore (Grid Groups 3,4a, 4b, 5,6)



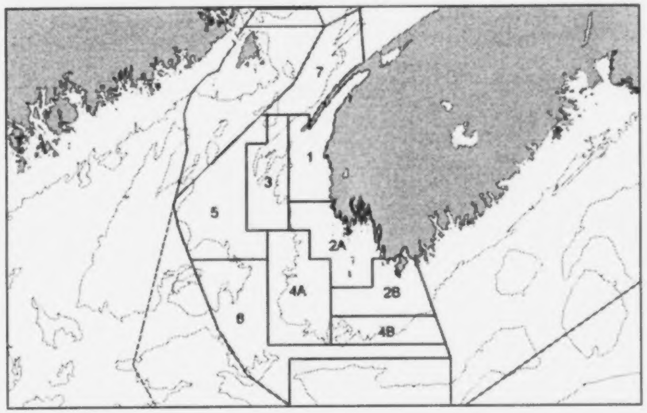
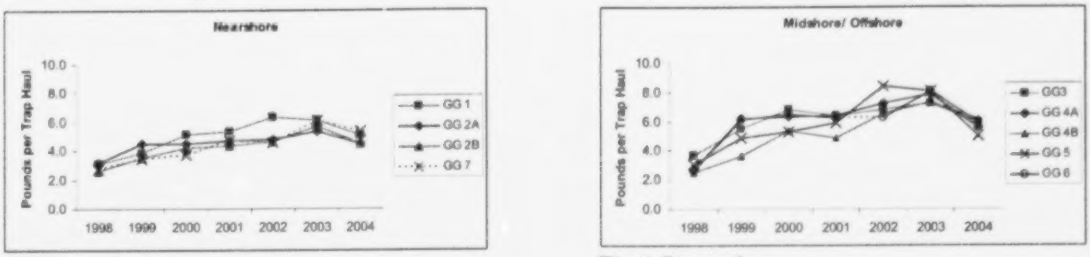
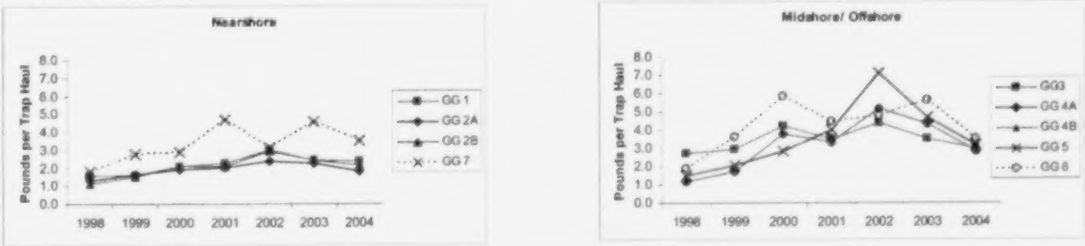


Figure 3.1.11 Proportion of overall landings by Grid Groups



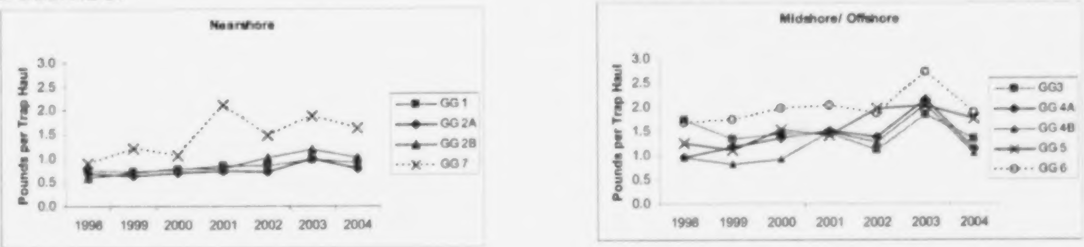
First 2 weeks

First 2 weeks



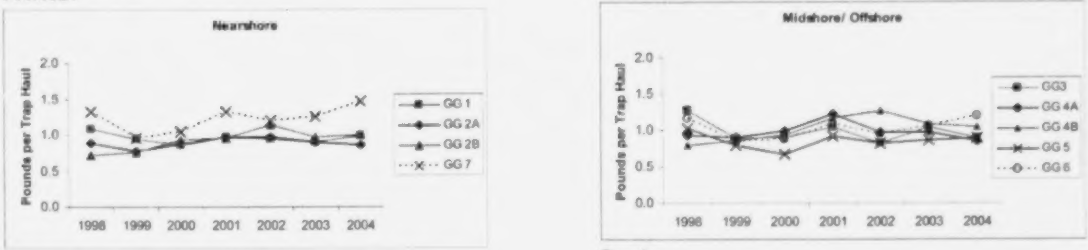
December

December



Winter

Winter



Spring

Spring

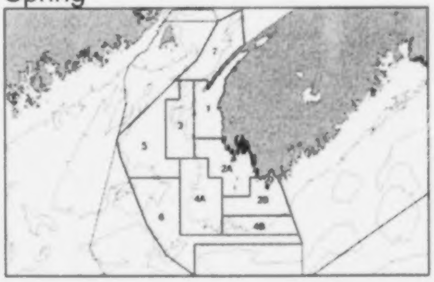


Figure 3.2.1 CPUE (pounds per trap haul) from LFA 34 log books by Grid Groupings and fishing period

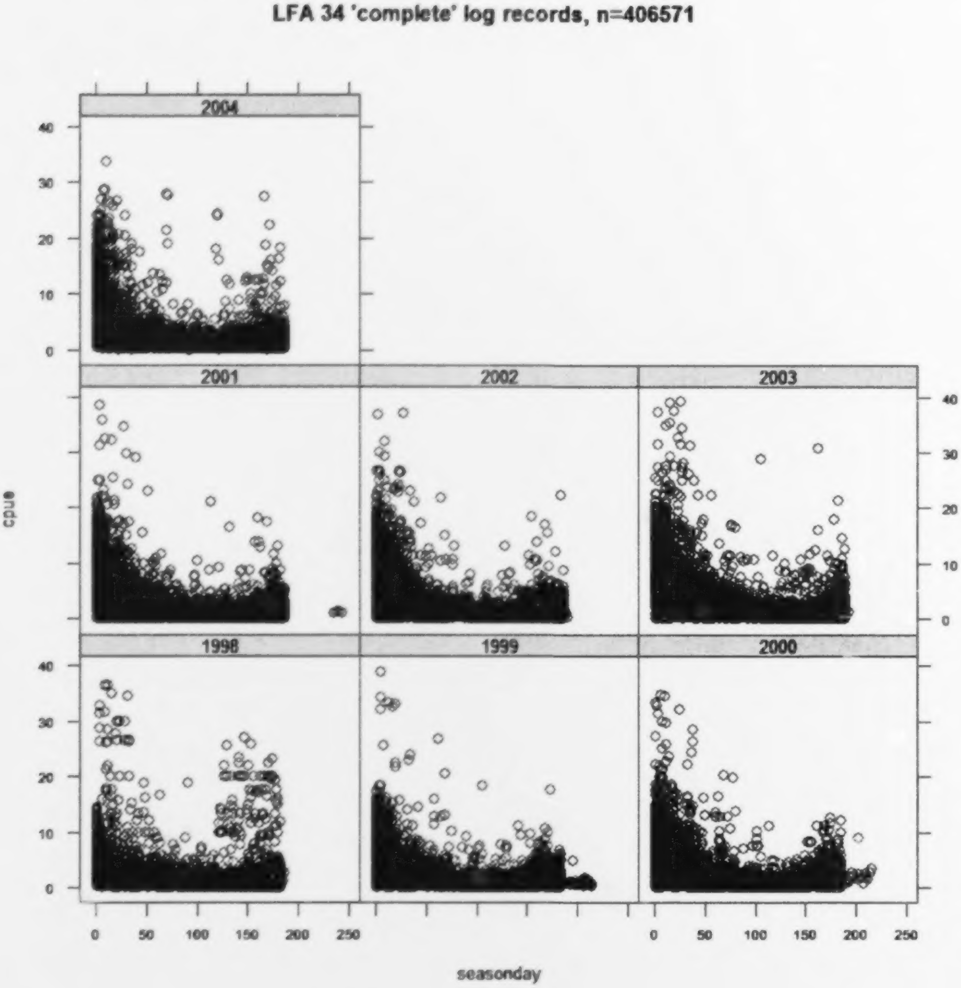


Figure. 3.3.1 Cpue (lb/trap haul) for all LFA 34 log book records with complete catch, effort and location information.

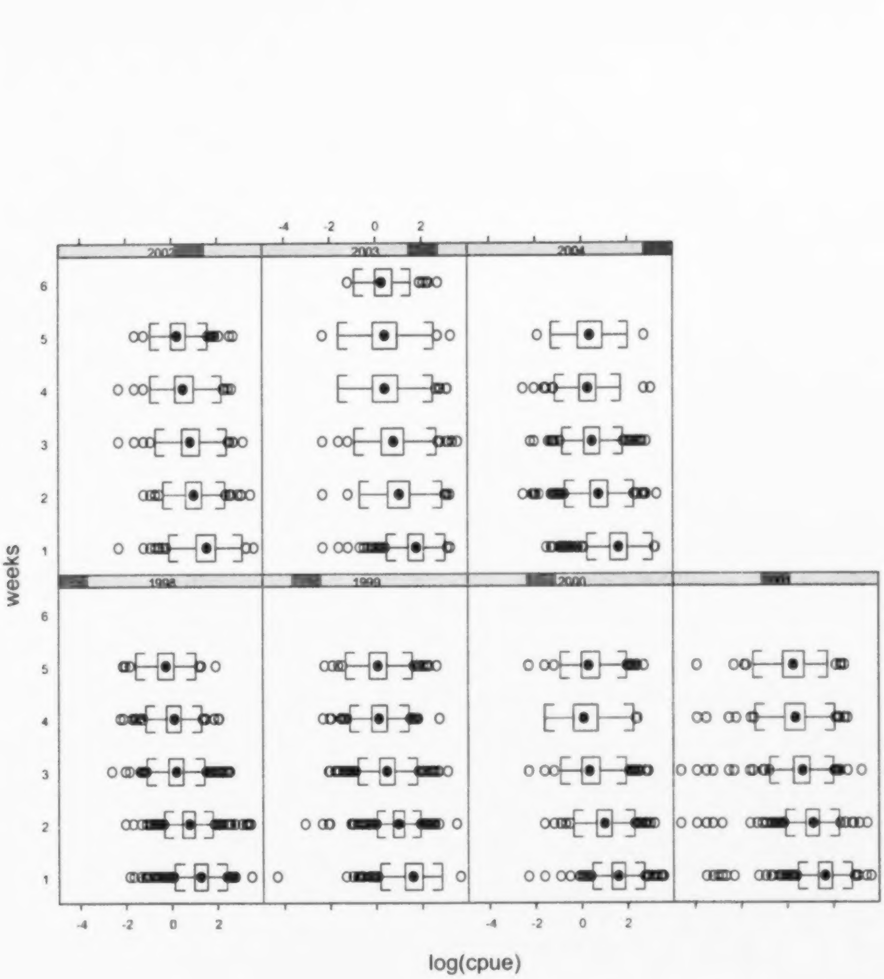


Figure. 3.3.2 Boxplot of Log (Cpue (lb/trap haul)) week in the season for LFA 34 log books in Grid Group 2a, fall period (season start until Dec. 31).
[`bwplot(wk.fac~log(CPUE)|yr,data=logtestdata,ylab="weeks")`]

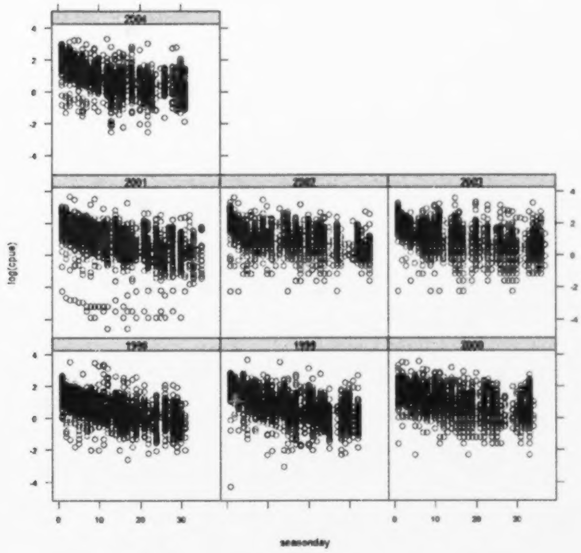


Figure. 3.3.3 Plot of log(CPUE) on seasonday for fall period (season start to Dec. 31 for Grid Group 2a.   All data

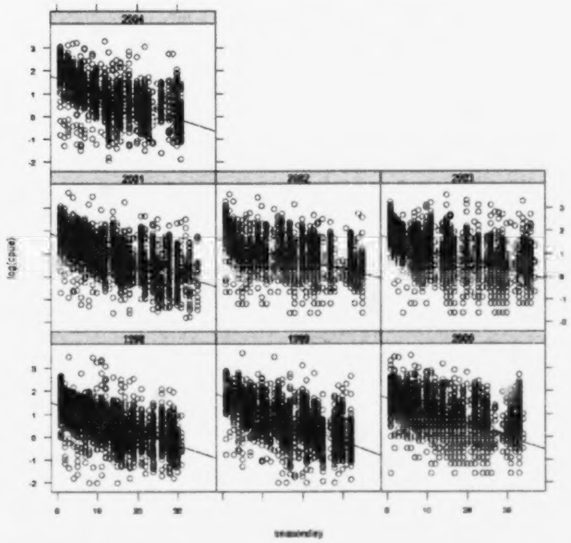


Figure. 3.3.4 As for Figure 3.3.2 but with CPUEs< 50/375 removed. Linear and non-linear lines fit to data [`xyplot(log(CPUE)~seasonday|yr,subset=CPUE>50/375, data=logsallfg2.1,panel=function(x,y){panel.xyplot(x,y) panel.loess(x,y)panel.lmline(x,y)})`]

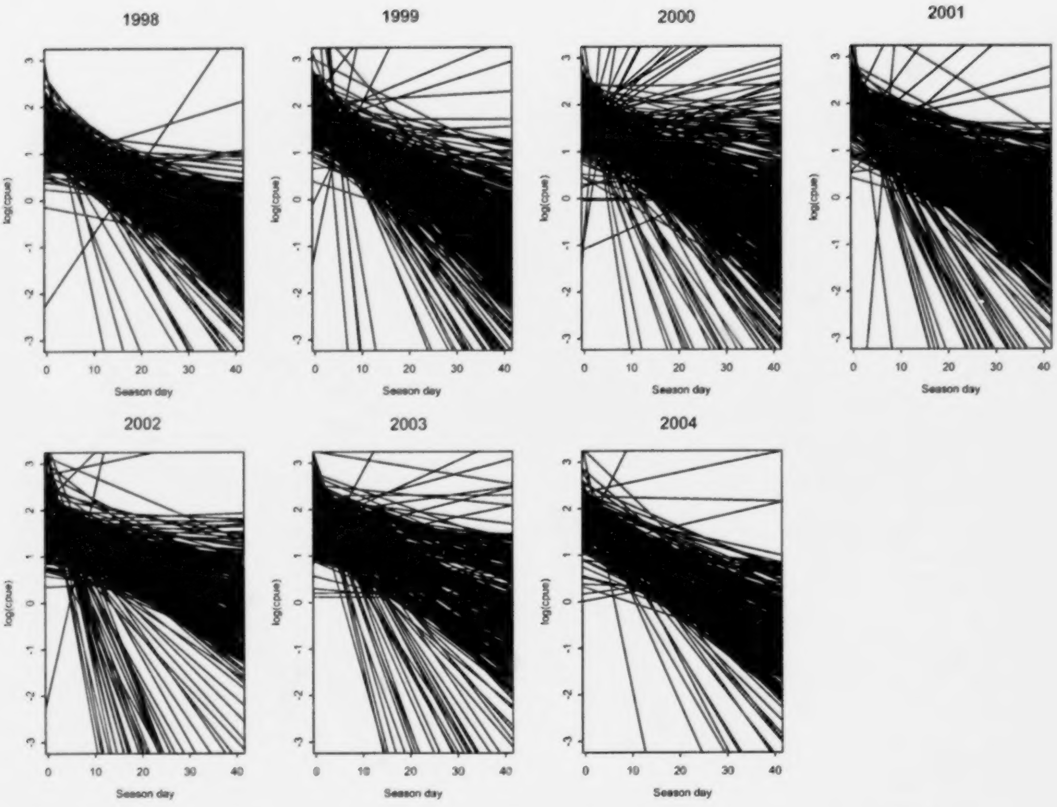


Figure. 3.3.5 The log linear model fit to the data for each of the licenses in Grid Group 2a, fall season.

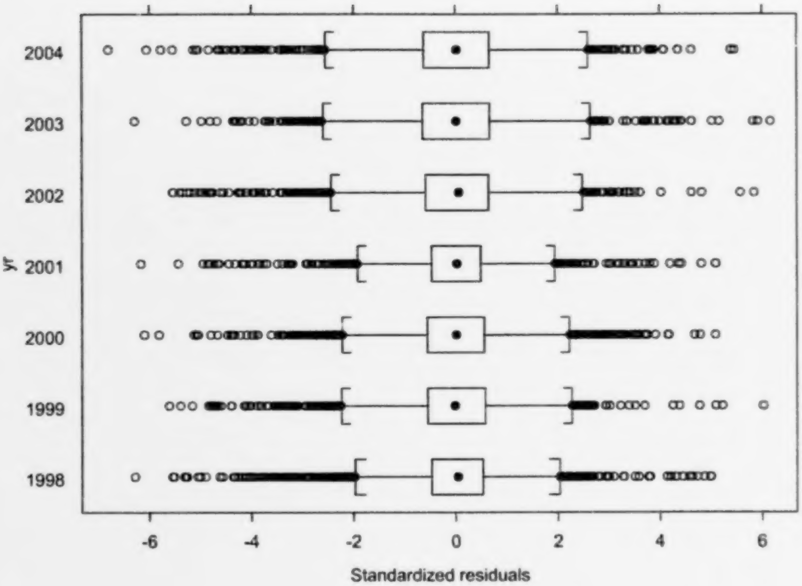


Figure. 3.3.6 Standardized residuals for each year in model on test data set (Grid Group 2a, fall season). See model output in Table 3.3.2. [`plot(logdata2.2.lme, form = yr ~ resid(., type = "p"))`]

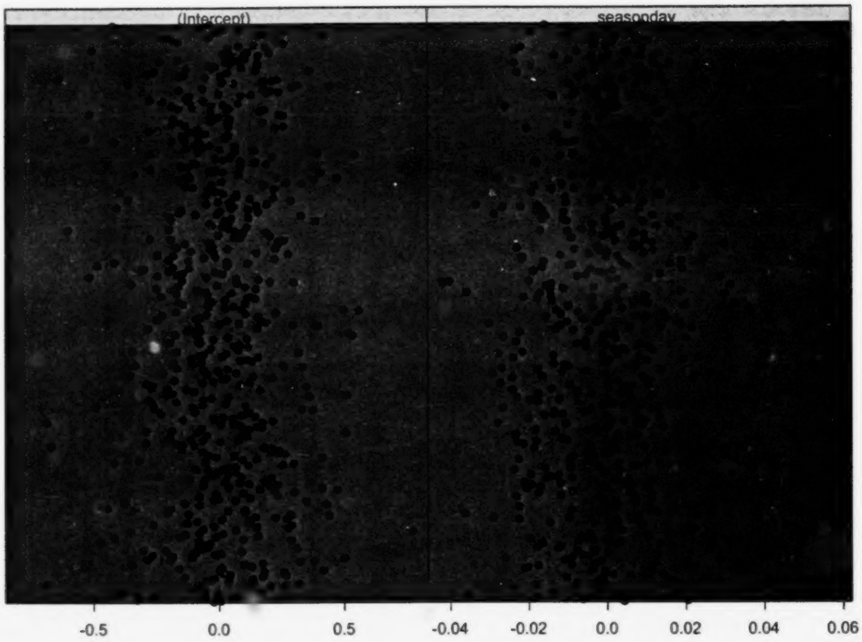


Figure. 3.3.7 Plots of the individual random effects by licence number i.e. the individual deviations from the mean (fixed effect) intercept and slope. Corresponding model output shown in Table 3.3.2). [`plot(ranef(logdata2.2.lme),level=1)`]

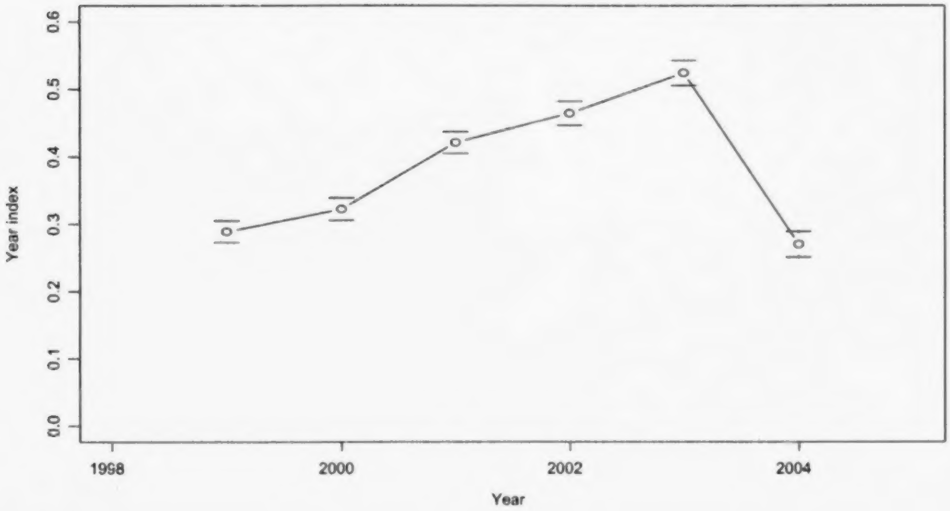


Figure. 3.3.8 Confidence intervals for each year (Grid Group 2a, fall period). Corresponding model output shown in Table 3.3.2). First year (1998-99) is intercept in Table 3.3.2 (=1.353); subsequent years are referenced to the intercept.

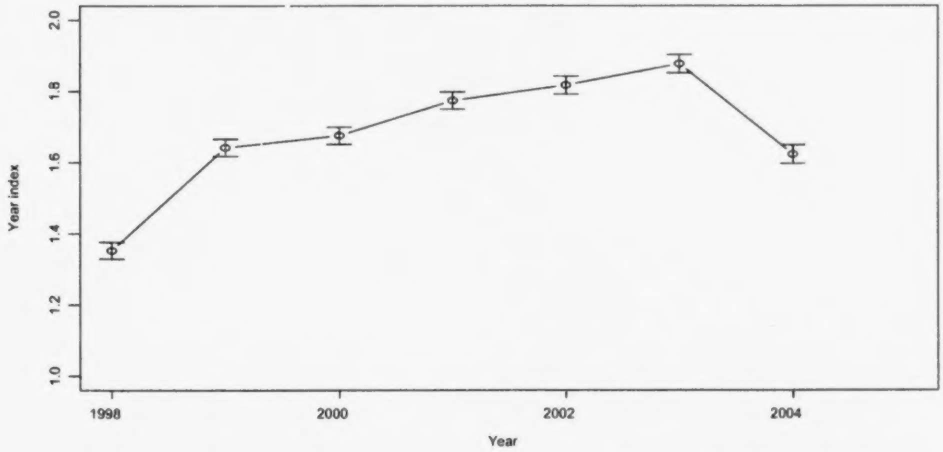
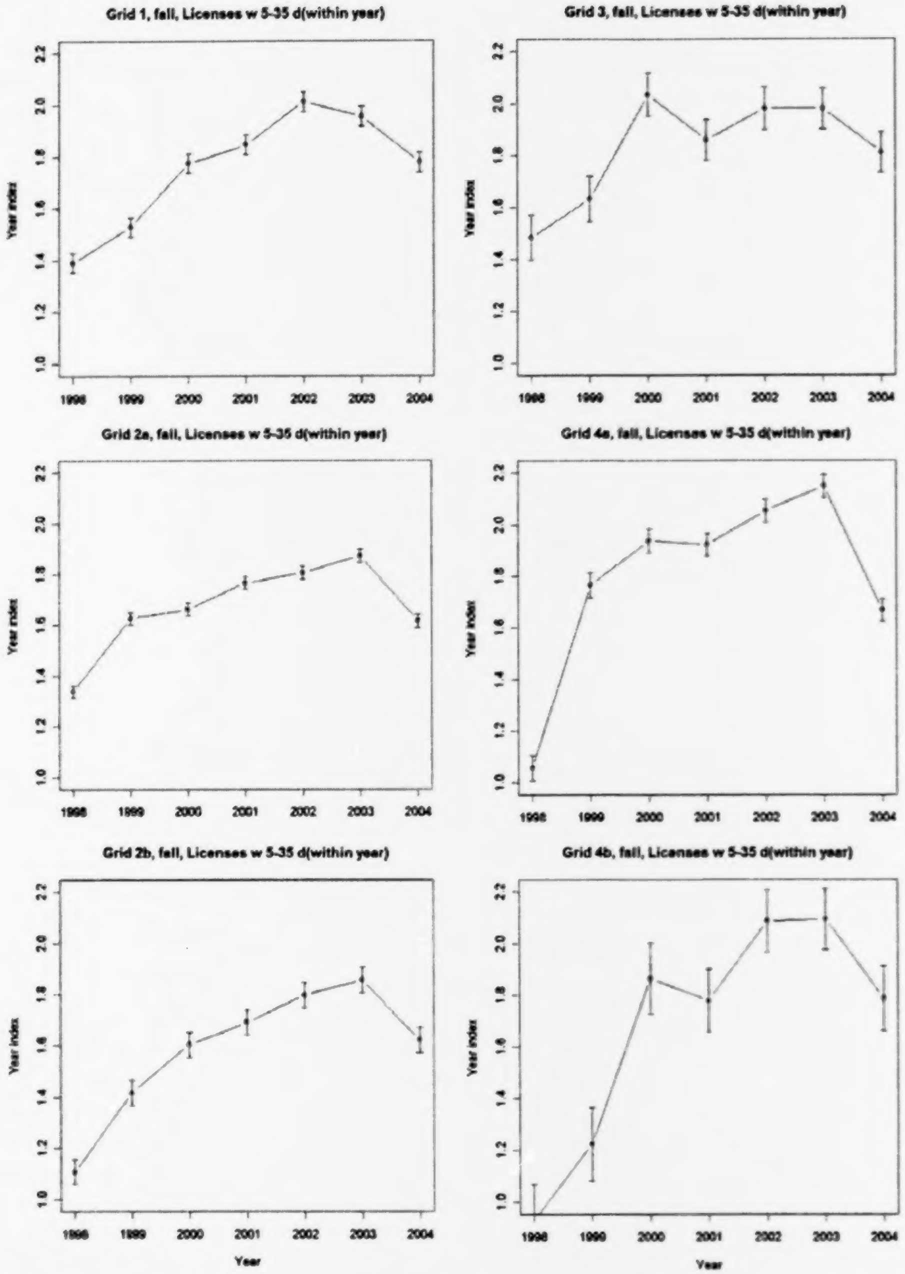


Figure. 3.3.9 Confidence intervals for each year (Grid Group 2a, fall period) with model refit to remove global intercept. Corresponding model output shown in Table 3.3.3).



Grid 1, fall, Licenses w 5-35 d(within year)

Grid 3, fall, Licenses w 5-35 d(within year)

Grid 2a, fall, Licenses w 5-35 d(within year)

Grid 4a, fall, Licenses w 5-35 d(within year)

Grid 2b, fall, Licenses w 5-35 d(within year)

Grid 4b, fall, Licenses w 5-35 d(within year)

Figure. 3.3.10 Cpue index, Fall period. Shown for each Grid Group is index and confidence intervals.

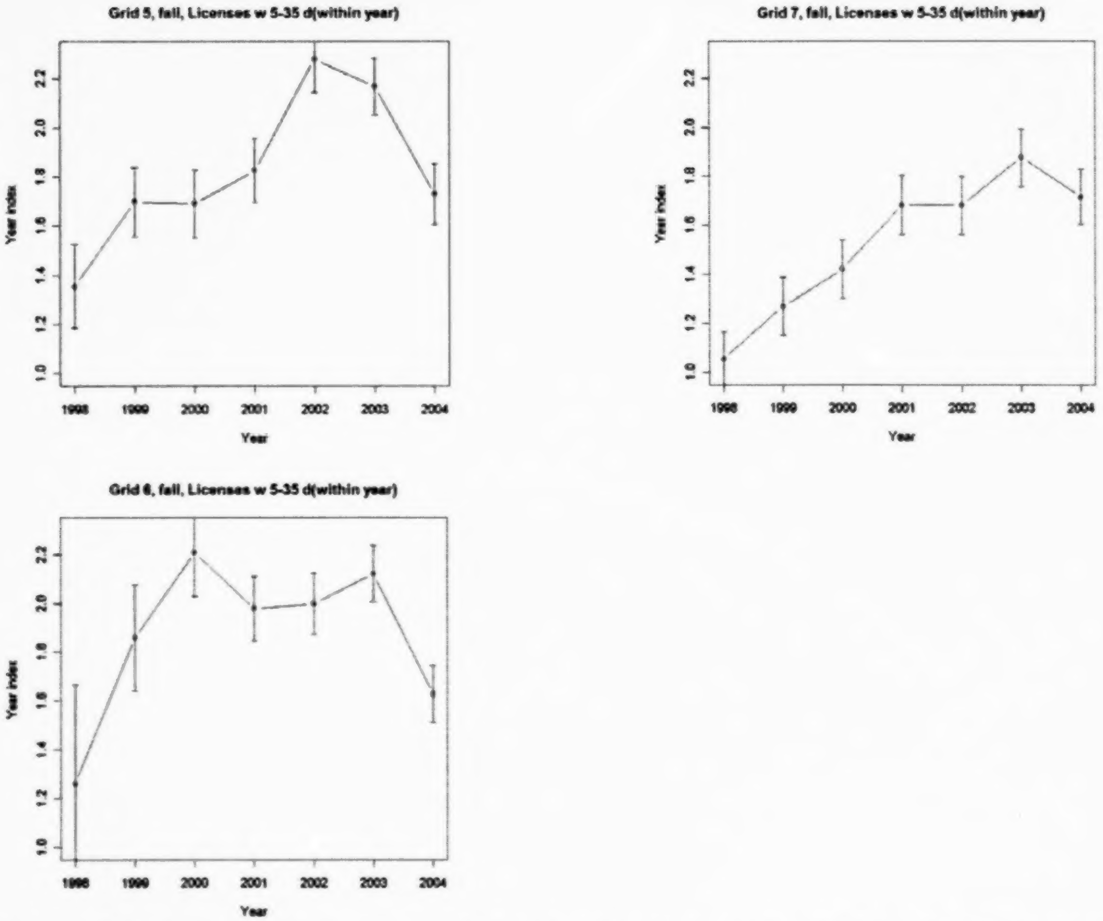


Figure. 3.3.10 continued Cpue index, Fall period. Shown for each Grid Group is index and confidence intervals.

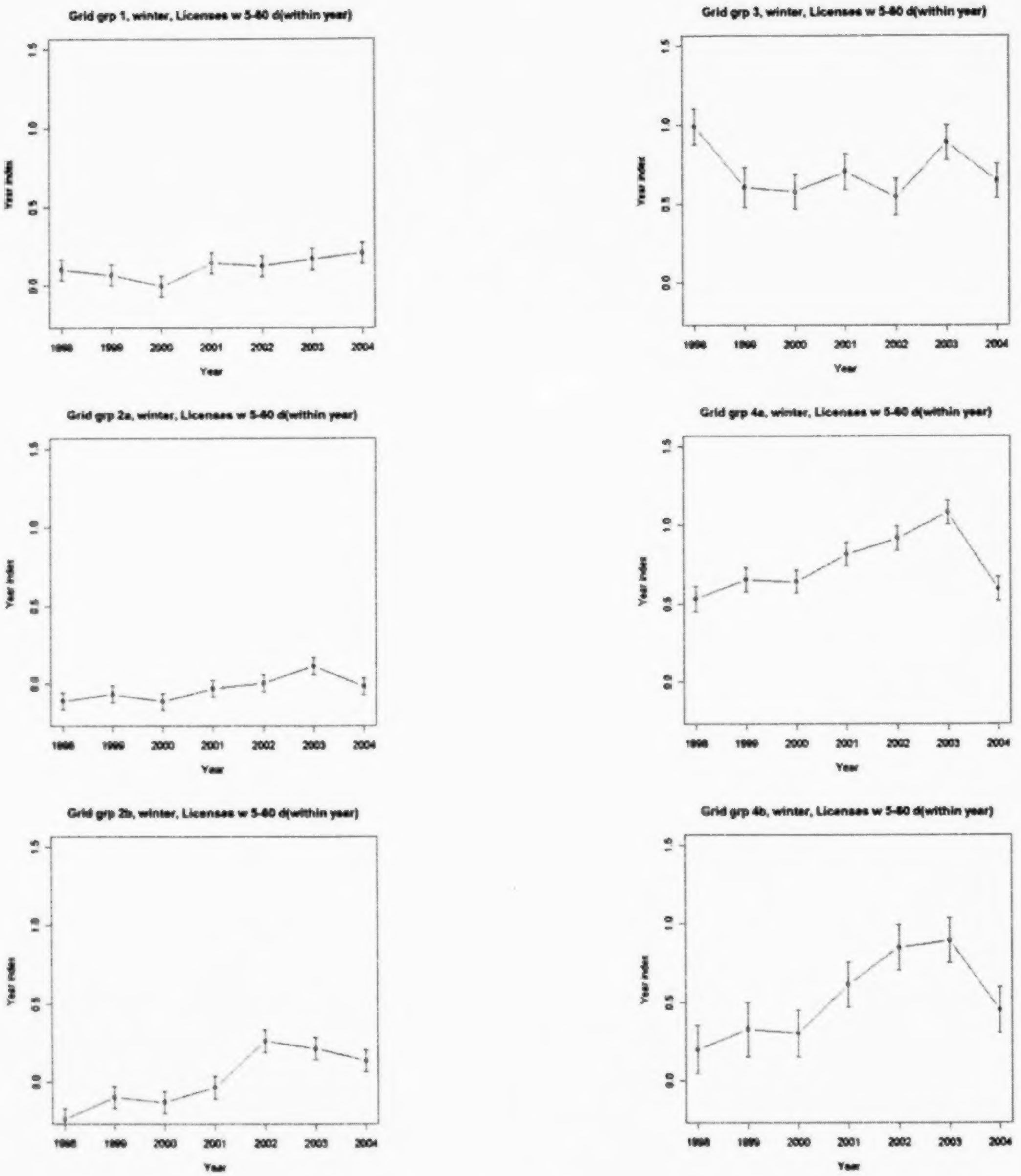
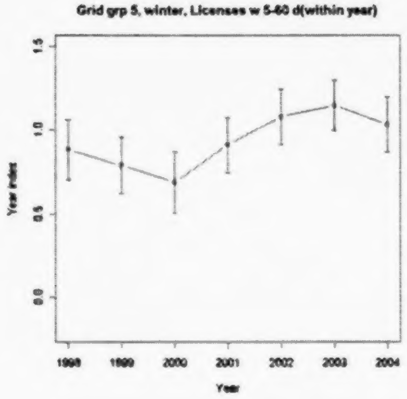
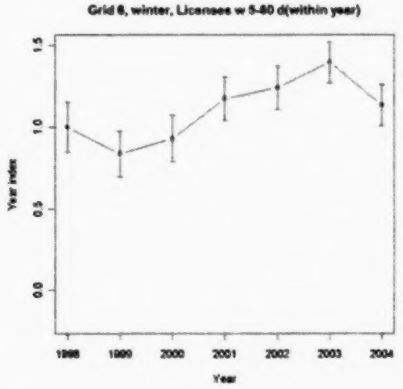


Figure. 3.3.11 Cpue index, Winter period. Shown for each Grid Group is index and confidence intervals.





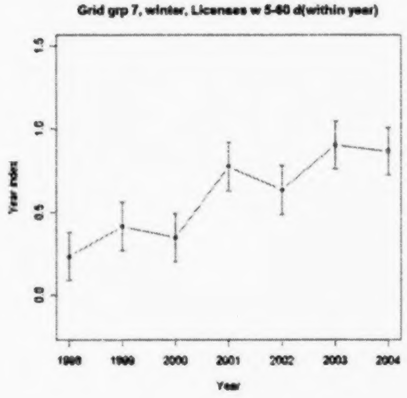


Figure. 3.3.11 Continued. Cpue index, Winter period. Shown for each Grid Group is index and confidence intervals.

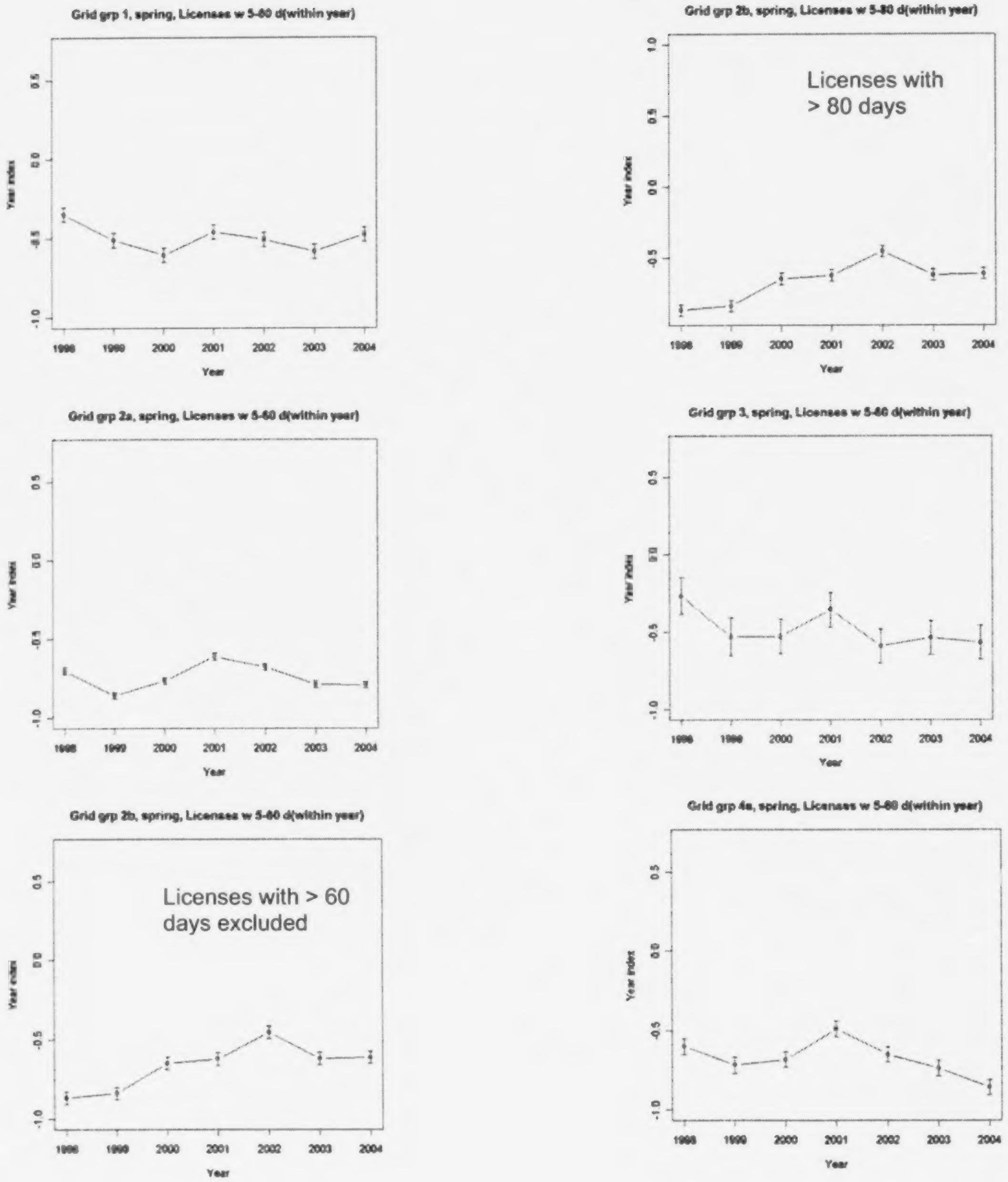


Figure. 3.3.12 Cpue index, Spring period. Shown for each Grid Group is index and confidence intervals.

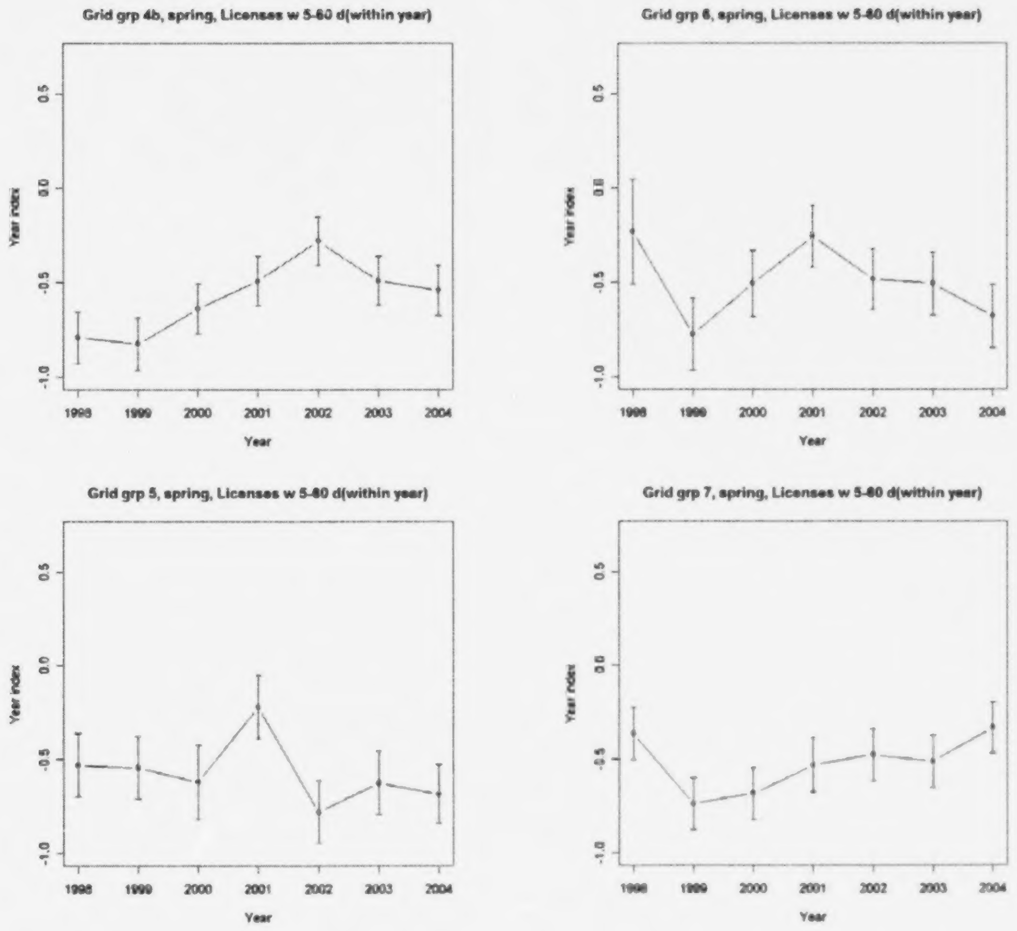


Figure. 3.3.12 Cont'd Cpue index, Spring period. Shown for each Grid Group is index and confidence intervals.

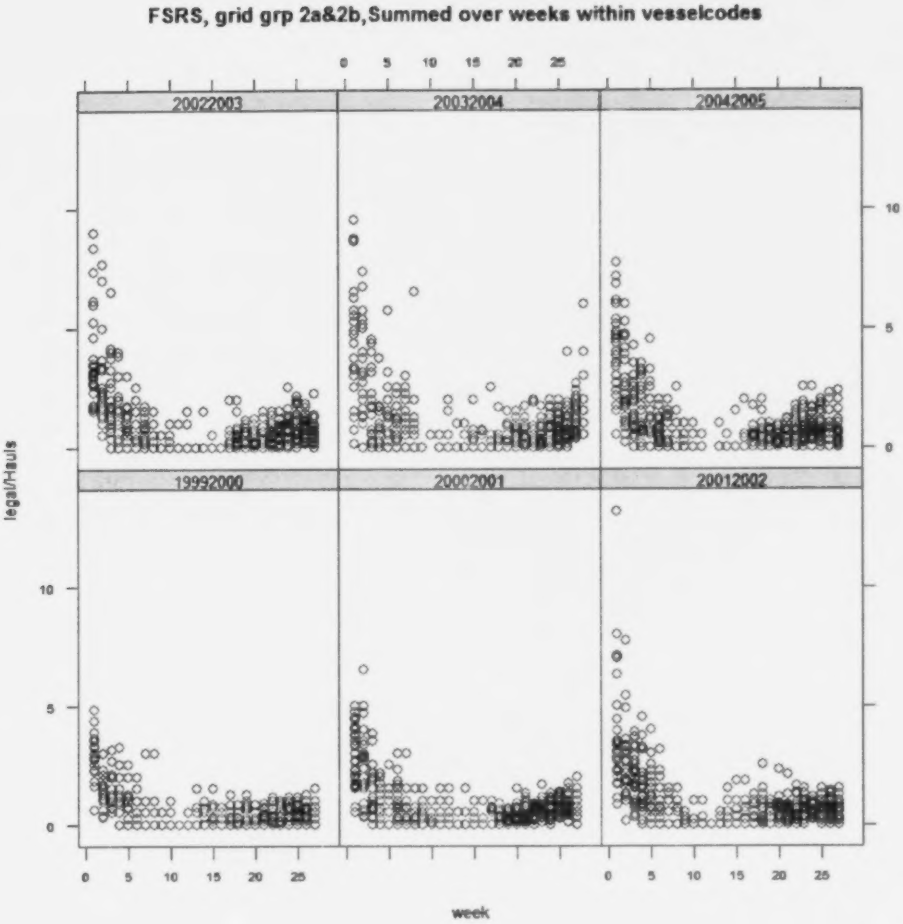


Figure 3.4.1 FSRS recruitment trap CPUE in Grid Group 2ab. Shown is legal number per trap haul grouped by weeks. Each point represents the CPUE of one fisherman (=vesselcode) for one week.

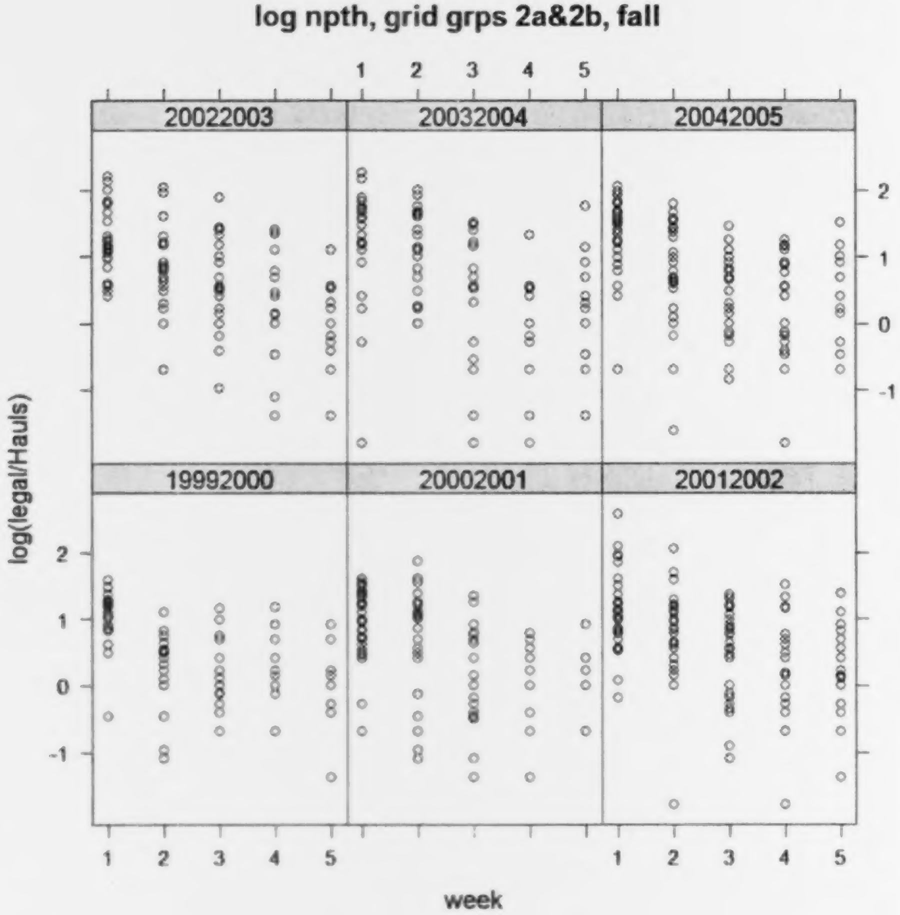


Figure 3.4.2 Log(No. per trap haul of legal sizes) in FSRS traps, fall, grid 2ab.

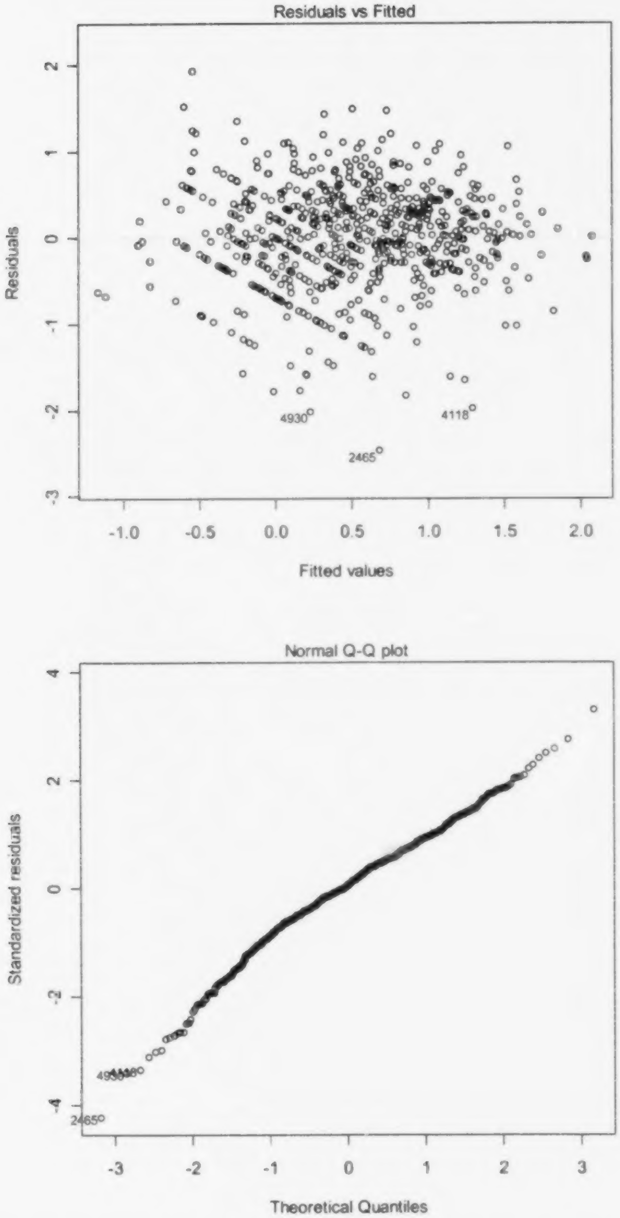


Figure 3.4.3 Quantile/Quantile residual plots for CPUE model applied to legal sizes in Grid Group 2ab, fall.

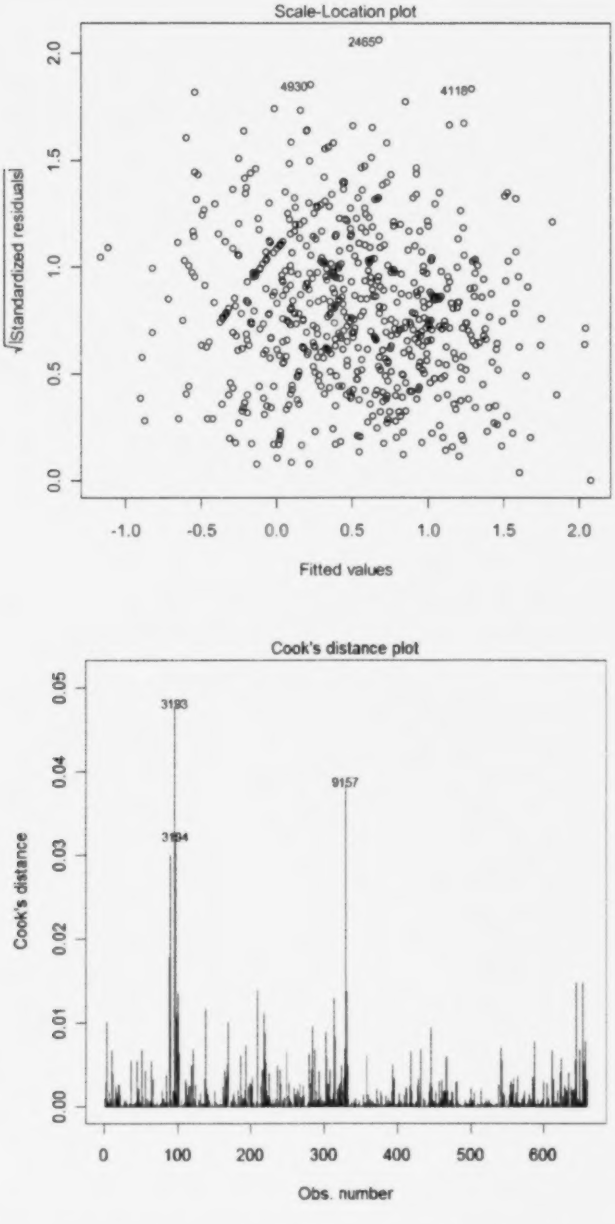


Figure 3.4.3 Cont'd. Residual plots for CPUE model applied to legal sizes in Grid Group 2ab, fall.

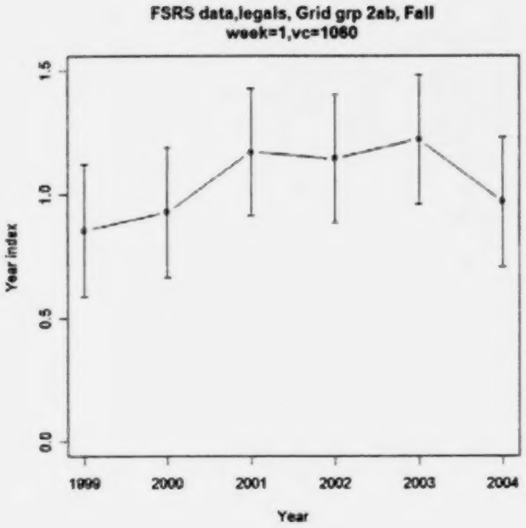


Figure 3.4.4 Cpue index and confidence intervals for legal sizes, Grid Group 2ab, fall. Derived from the model of log (no. per trap haul) on week, season and vesselcode fit without the global intercept. Index is standardized to week=1 and for a particular vesselcode.

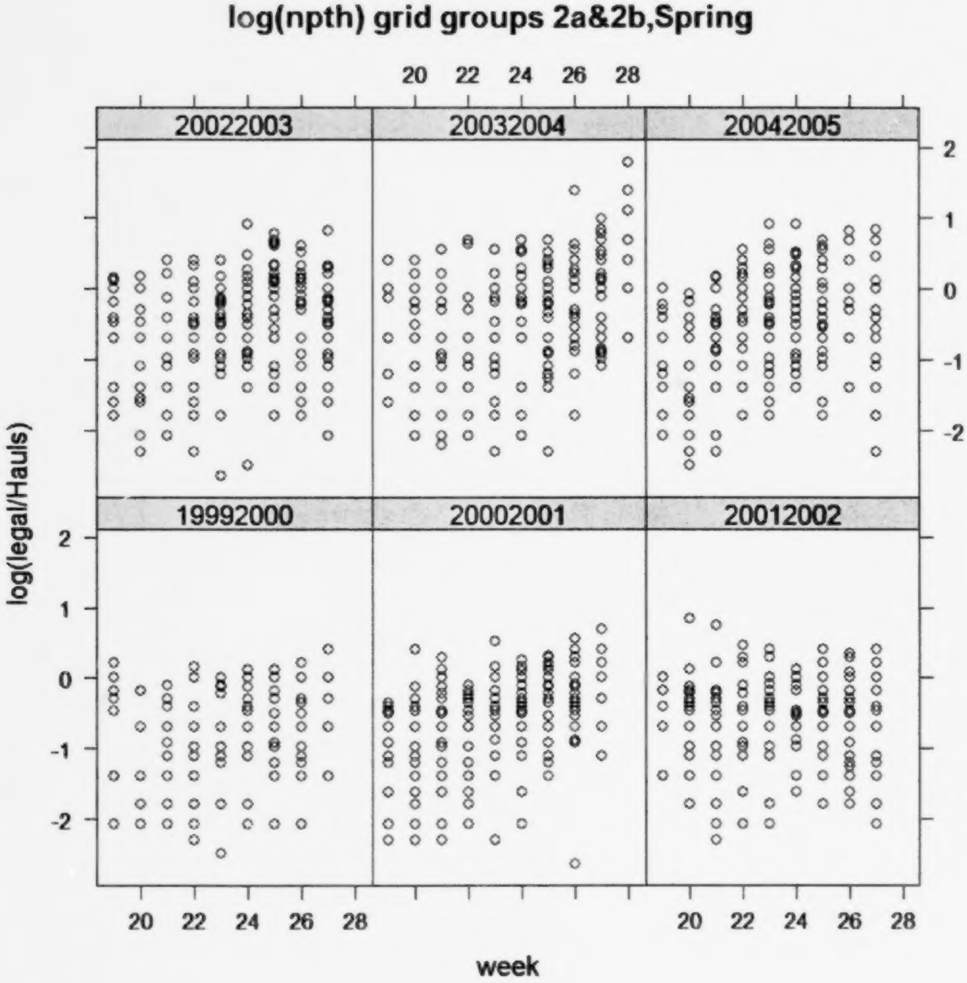


Figure 3.4.5 Log(No. per trap haul of legal sizes) in FSRS traps, spring, grid 2ab. Season weeks begin on week 19 (late March or early April depending on season start date).

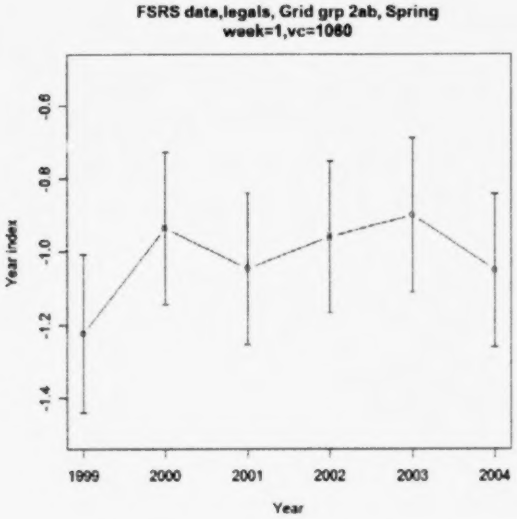


Figure 3.4.6 Cpue index and confidence intervals for legal sizes, Grid Group 2ab, spring. Derived from the model of log (no. per trap haul) on week, season and vesselcode fit without the global intercept. Index is standardized to week=1 and for a particular vesselcode.

```
ci.intout<-predict(fsrsmfbgrp.2ab.sprg.legal.lm1,newdata=refintout2,
interval="confidence",type="response")
> refintout2
  week2   Season VesselCode
1     1 19992000       1060
2     1 20002001       1060
3     1 20012002       1060
4     1 20022003       1060
5     1 20032004       1060
6     1 20042005       1060
```

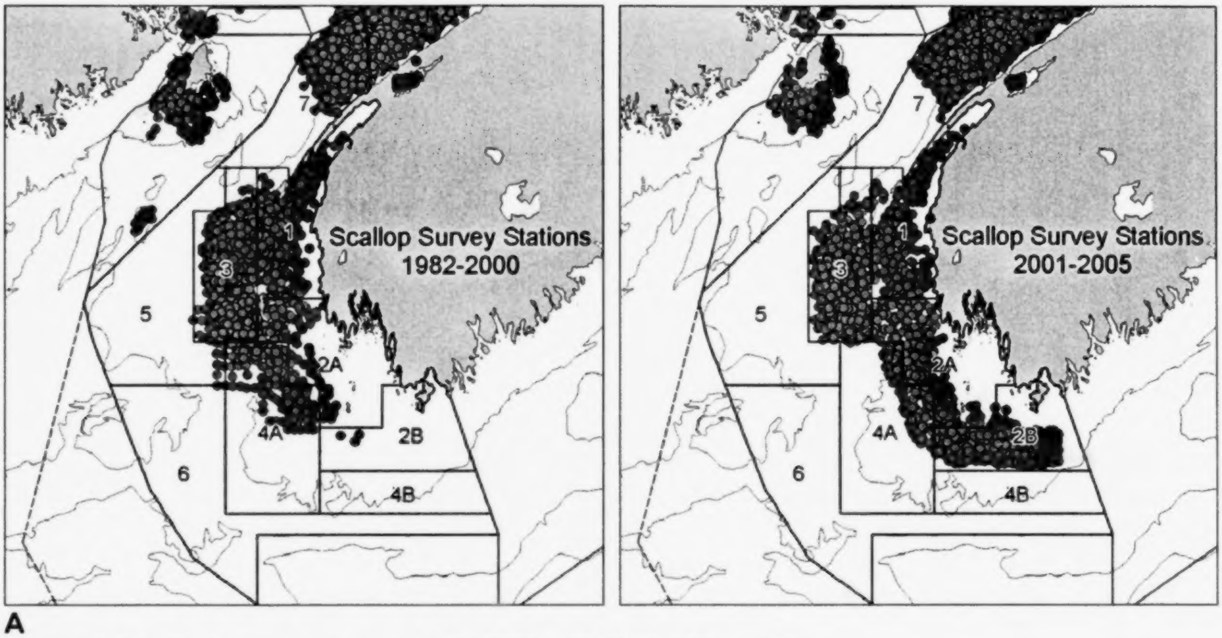


Figure 3.5.1 Scallop survey locations **A)**1982 – 2000 **B)** 2001 – 2005

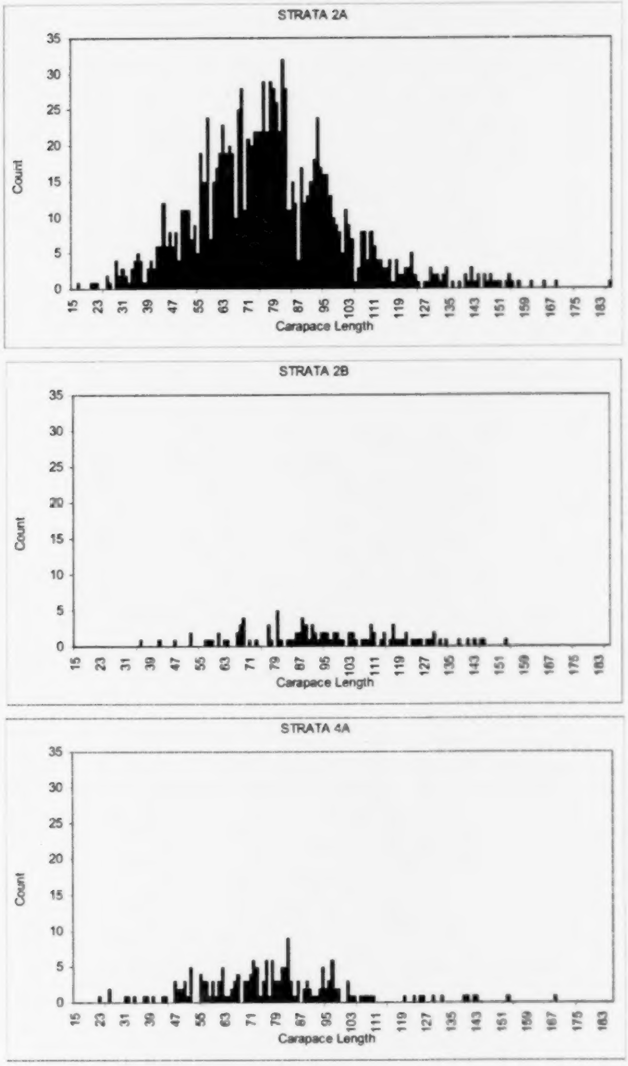


Figure 3.5.2 Size frequency of lobsters captured in all scallop surveys by Grid Group.

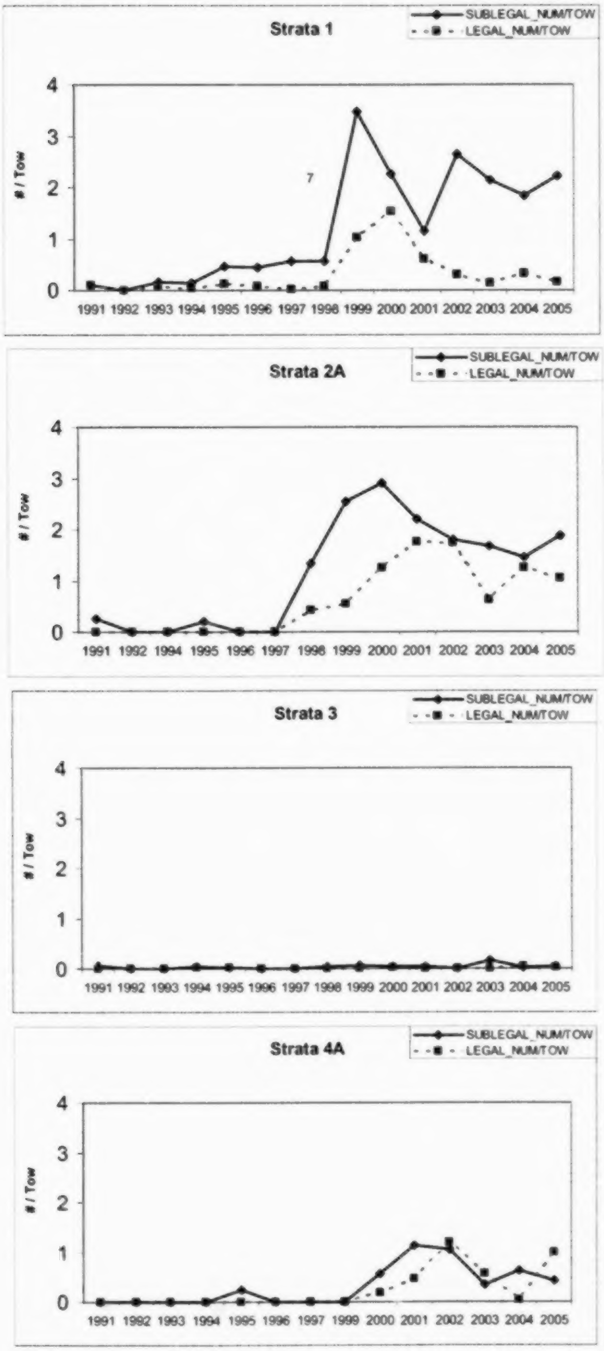


Figure. 3.5.3 Lobster catch rate in scallop surveys for different Grid Groups. Shown is the mean number of lobsters captured per tow. The catch rate is shown for two sizes of lobster: < 82mm CL and greater than 82mm CL.

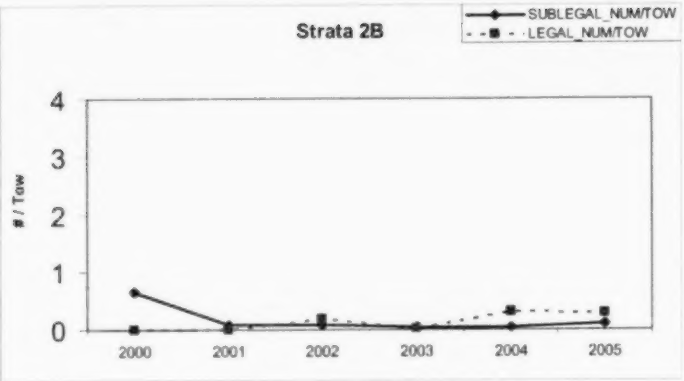


Figure. 3.5.4 Lobster catch rate in scallop surveys for Grid Group 2b. Data are available only since 2000. Shown is the mean number of lobsters captured per tow. The catch rate is shown for two sizes of lobster: < 82mm CL and greater than 82mm CL.

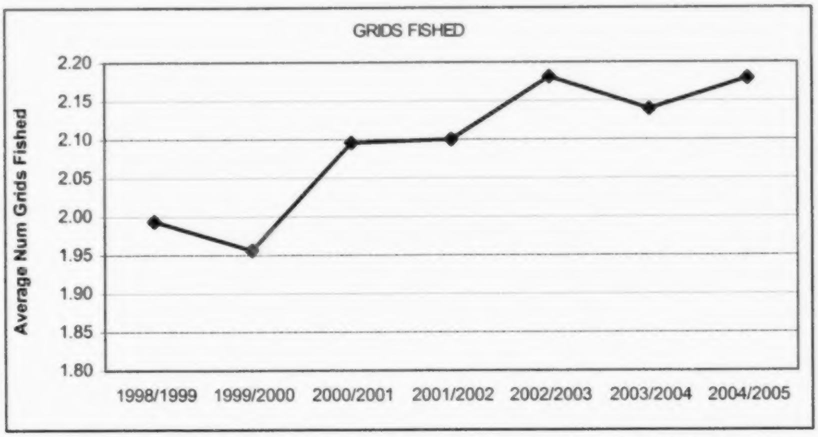


Figure 4.1.1 Average number of grids fished per fishermen in LFA 34 by season

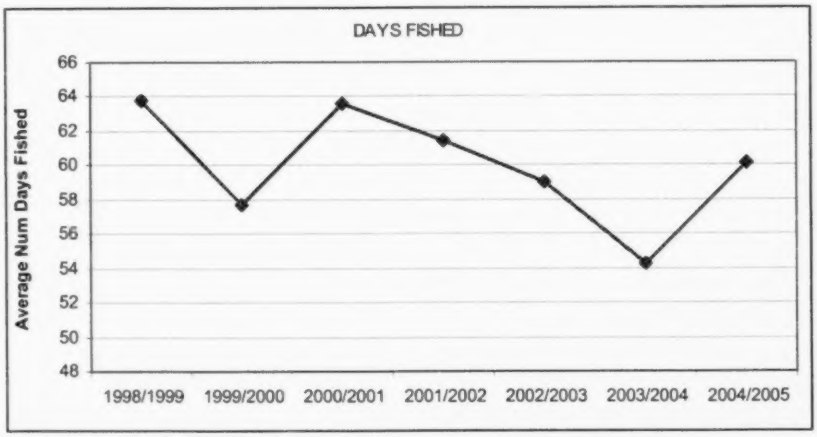


Figure 4.1.2 Average number of days fished per fishermen in LFA 34 by season

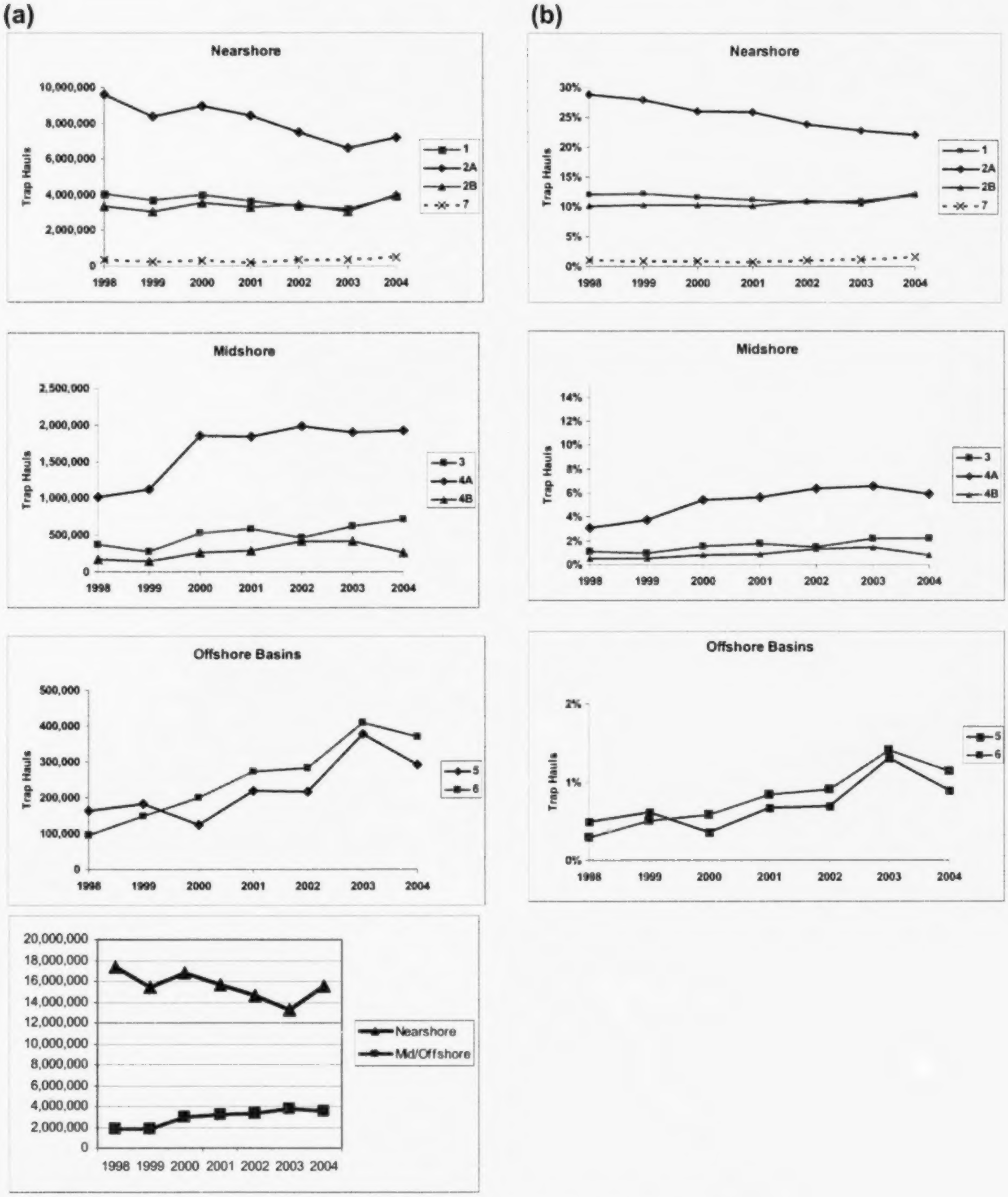
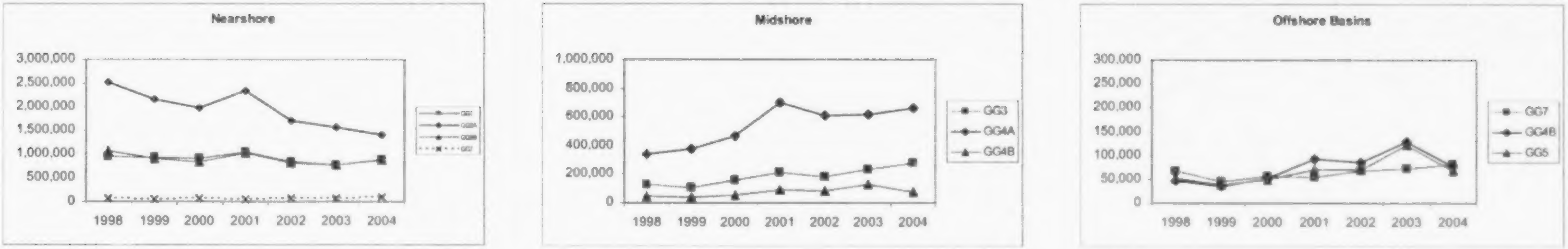
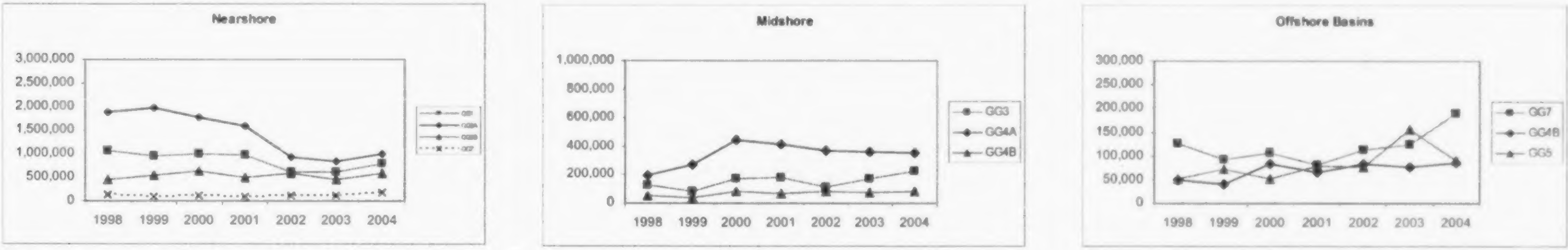


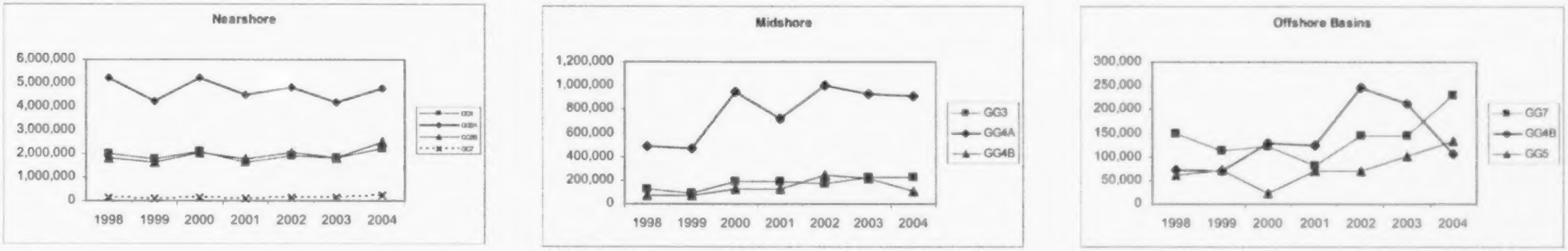
Figure 4.1.3 Total trap hauls from LFA 34 log books by Grid Groupings
(a) Total trap hauls; (b) Trap hauls as a percentage of total



Fall Fall Fall

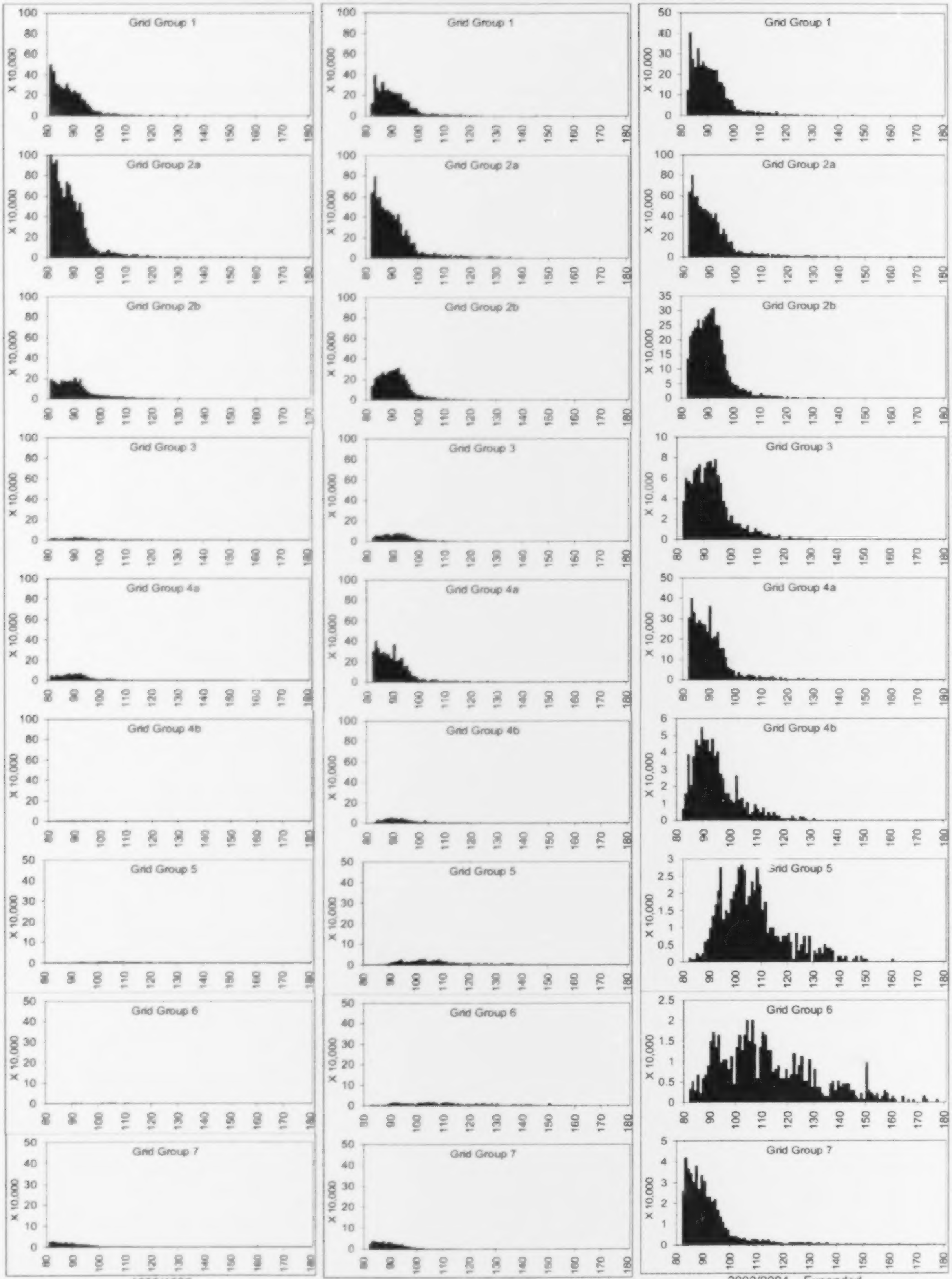


Winter Winter Winter



Spring Spring Spring

Figure 4.1.4 Total trap hauls from LFA 34 log books by Grid Groupings and fishing period

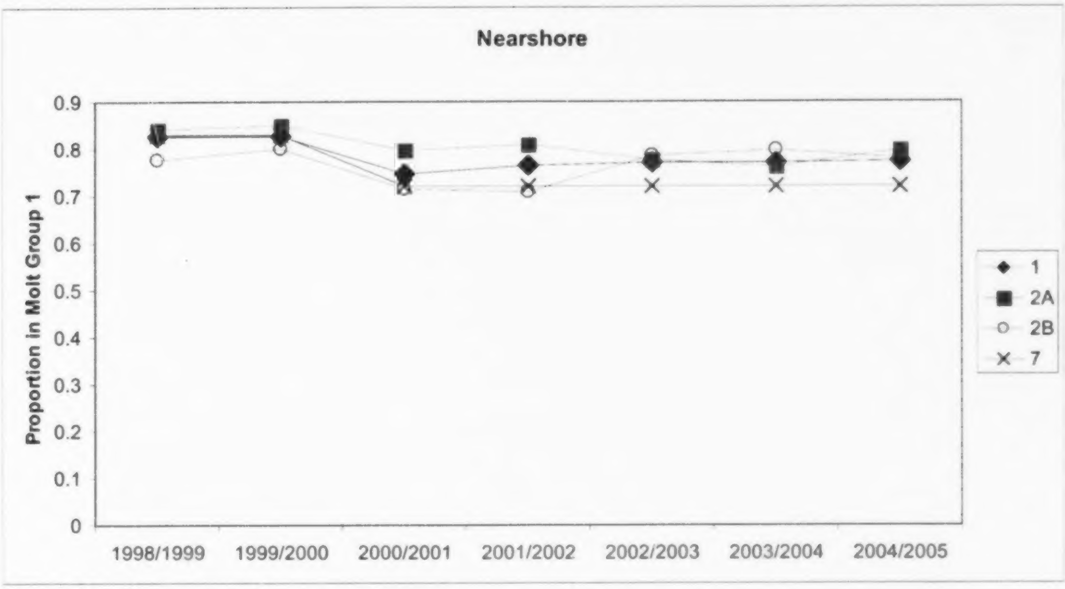


1998/1999

2003/2004

2003/2004 – Expanded

Figure 4.2.1 Numbers landed at size by Grid Group



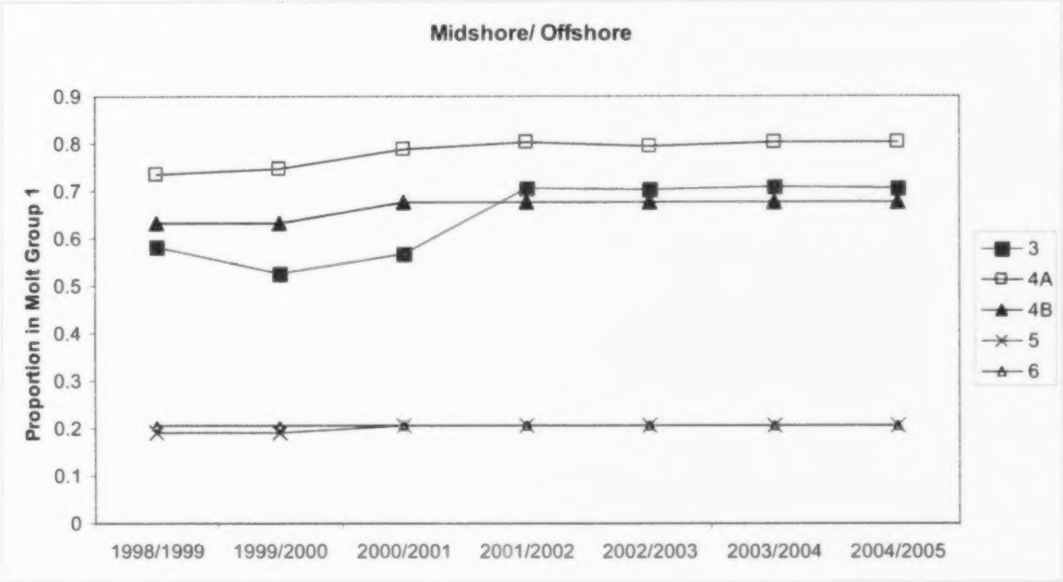


Figure 4.2.2 Proportion of lobsters in the first molt group by Grid Group

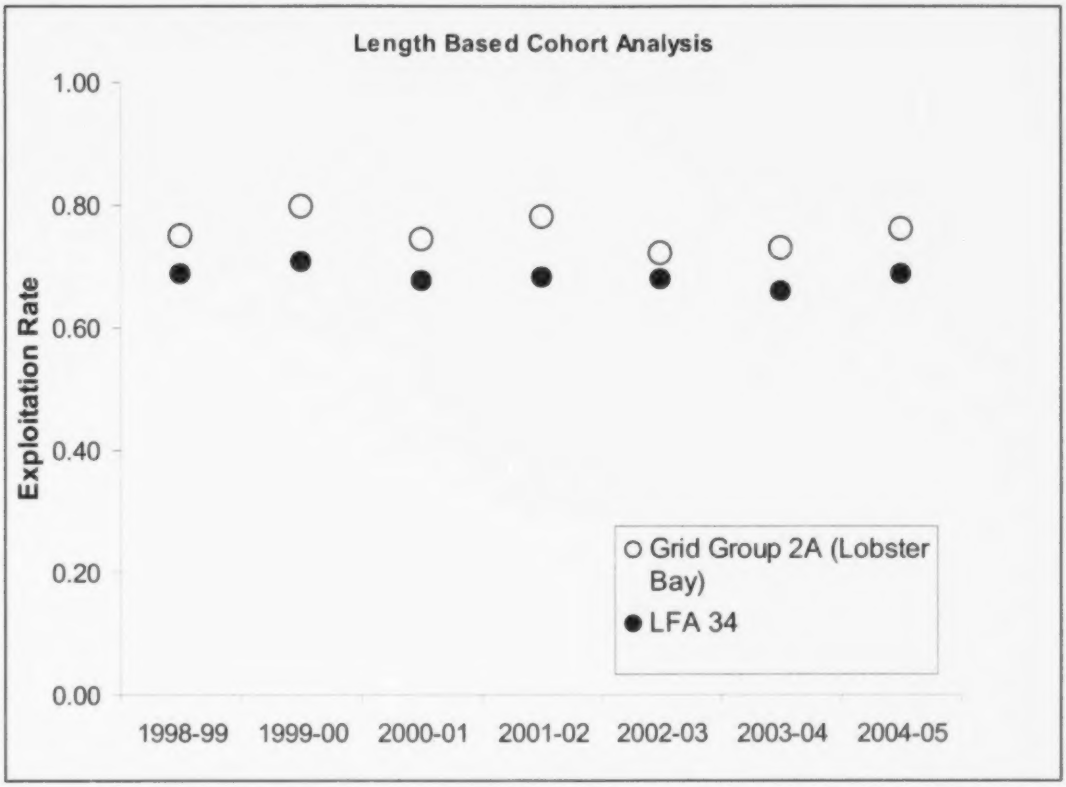


Figure 4.3.1 Estimates of exploitation rates for LFA 34 and Grid Group 2a based on the Length Based Cohort Analysis (LCA)

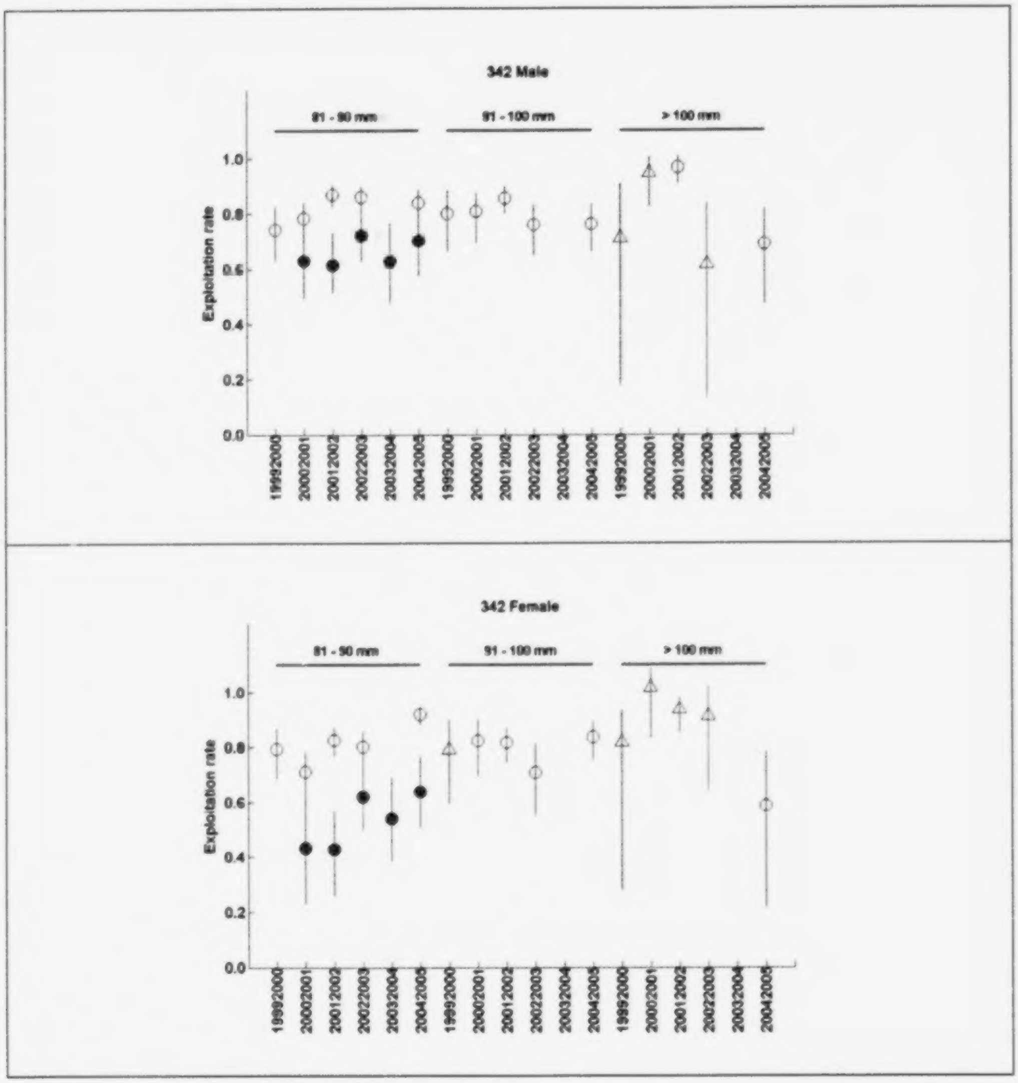


Figure 4.4.1 Strict exploitation rate estimates (open markers) and extended exploitation rate estimates (closed markers) for Grid Groups 2a and 2b combined. Most reliable estimates, sample size for reference and exploited groups >200 (circle markers), those less reliable because at least one of the reference or exploited groups had <200 but >100 lobster (triangle marker). Where no estimate was shown parameter estimates were either not significant or sample size for at least one of reference and exploited groups was <100.

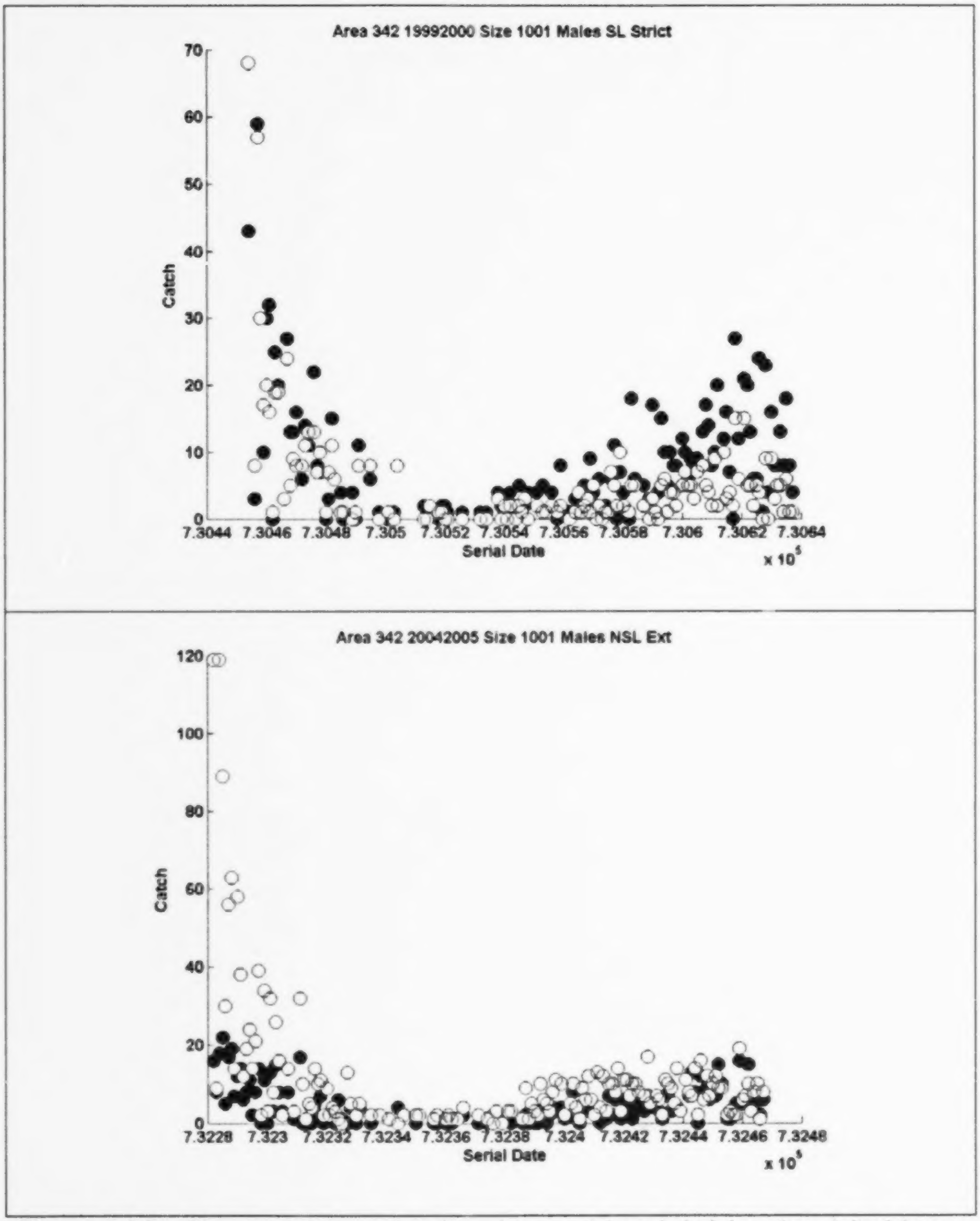


Figure 4.4.2a Observed data by date for reference (closed circle) and exploited (open circle) for selected seasons and sex.

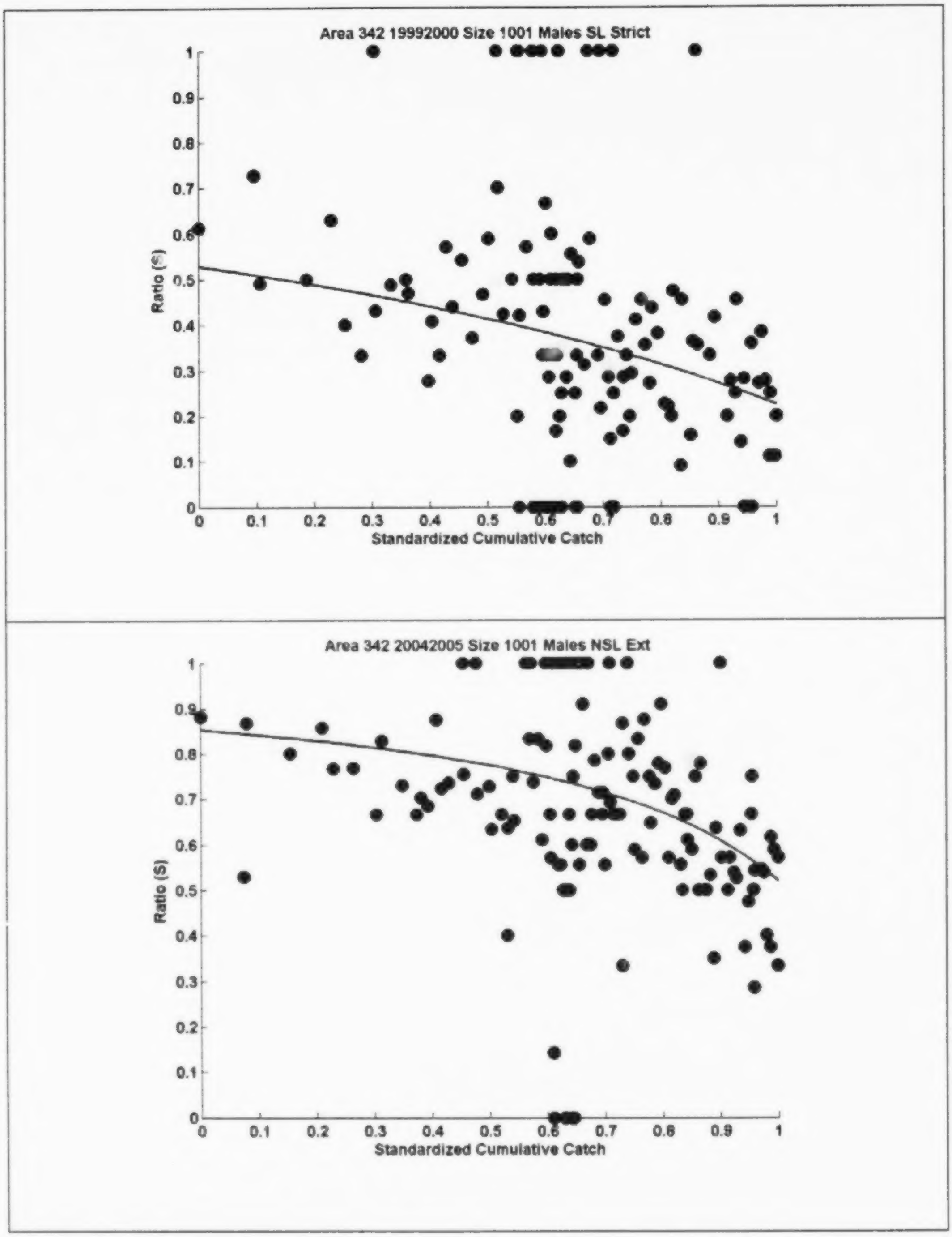


Figure 4.4.2b Observed ratio of reference to sum of reference + exploited lobster (closed circle) and estimated change in ratio (solid line) for indicated season and sex.

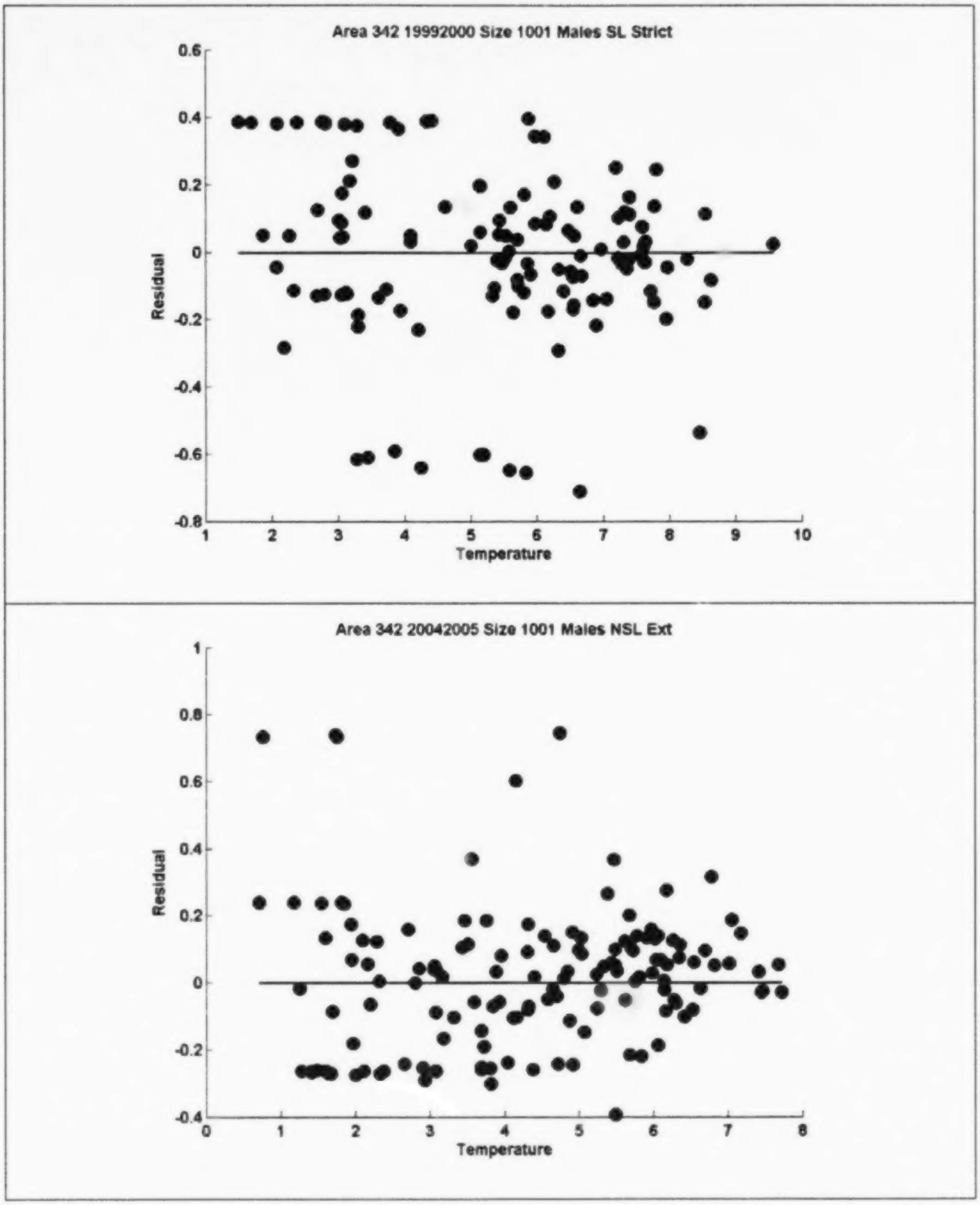


Figure 4.4.2c Residuals versus temperature for change-in-ratio model for indicated seasons and sex.

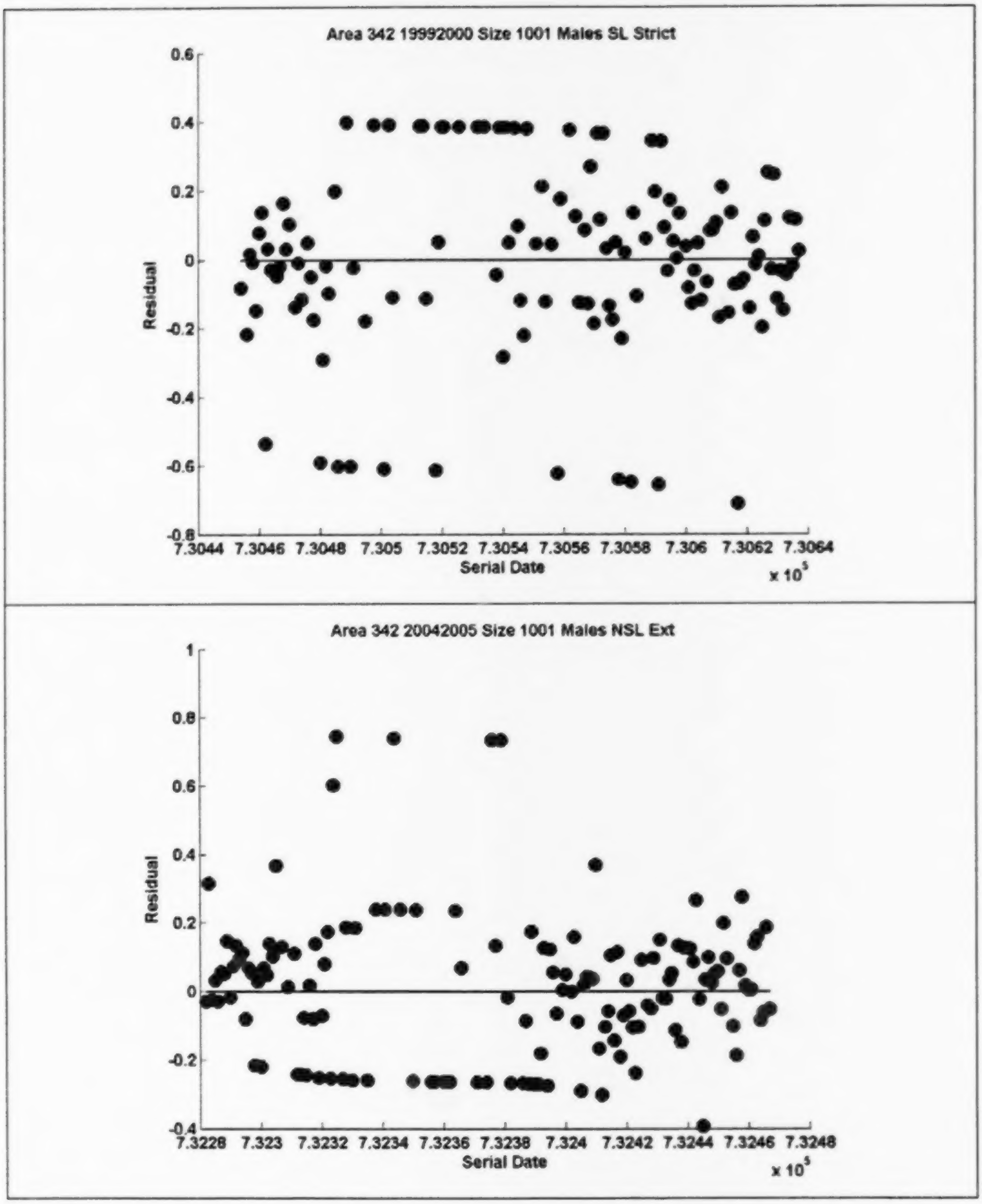


Figure 4.4.2d Residuals versus date for change-in-ratio model for indicated seasons.

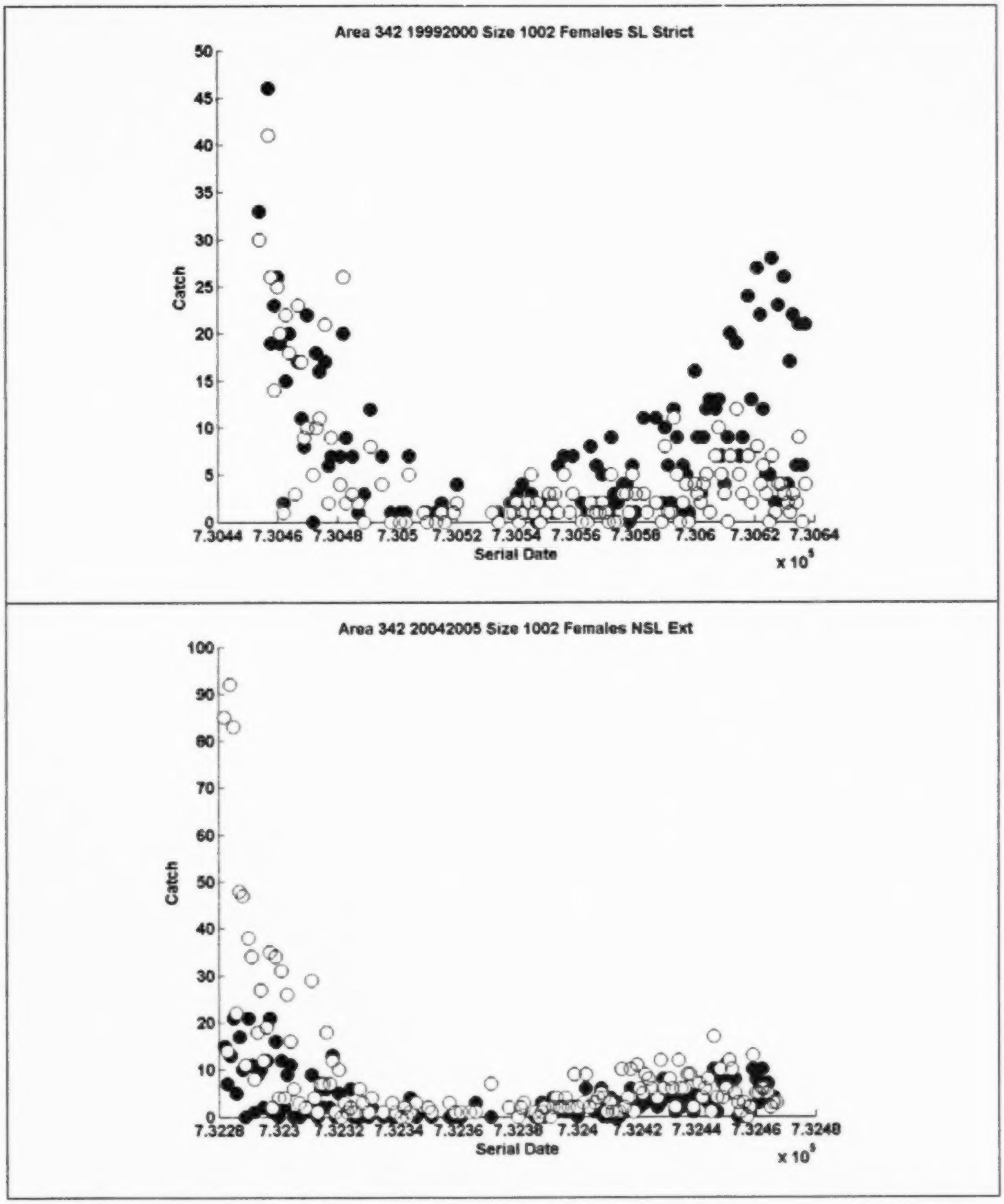


Figure 4.4.2e Observed data by date for reference (closed circle) and exploited (open circle) for selected seasons and sex.

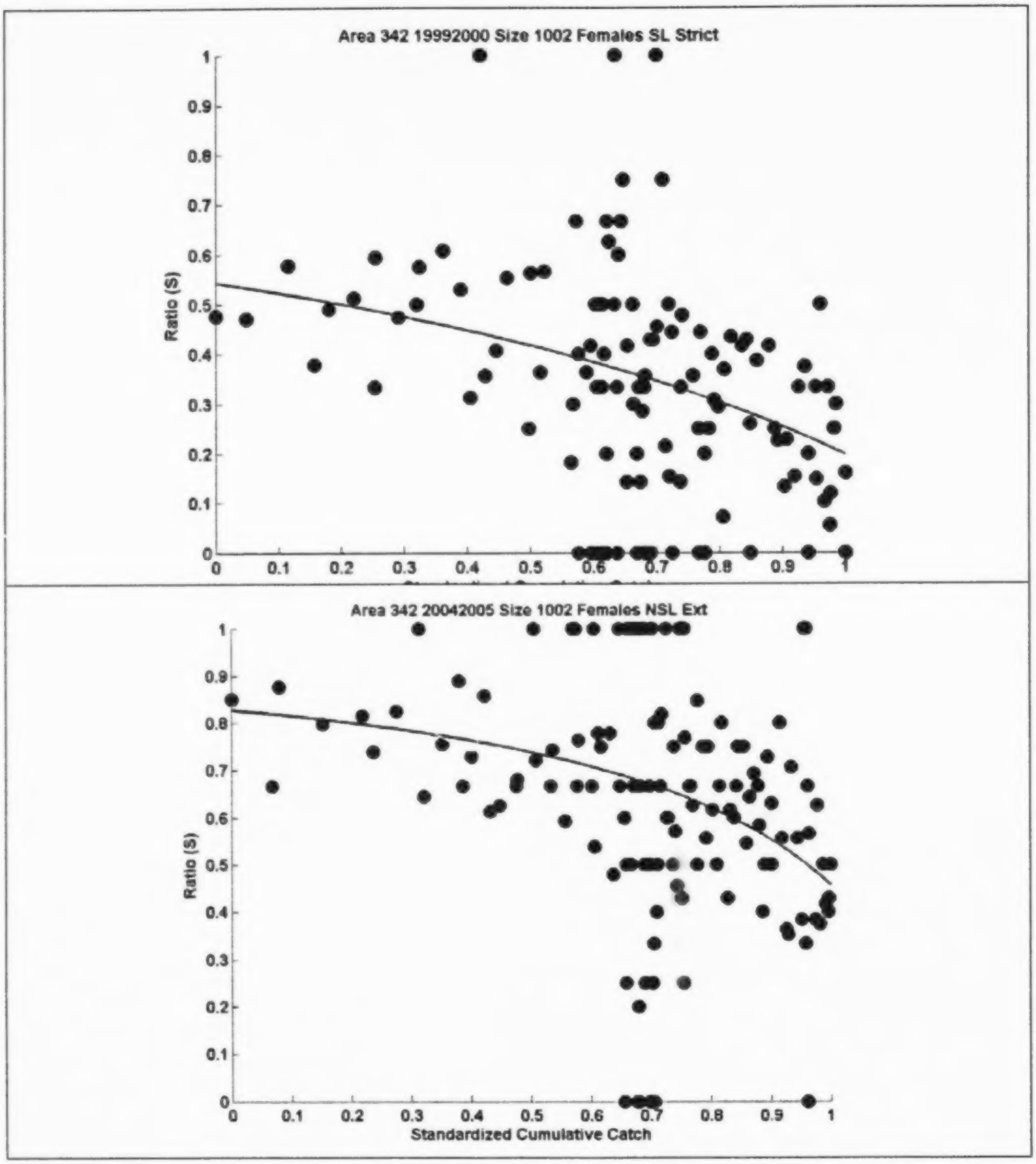
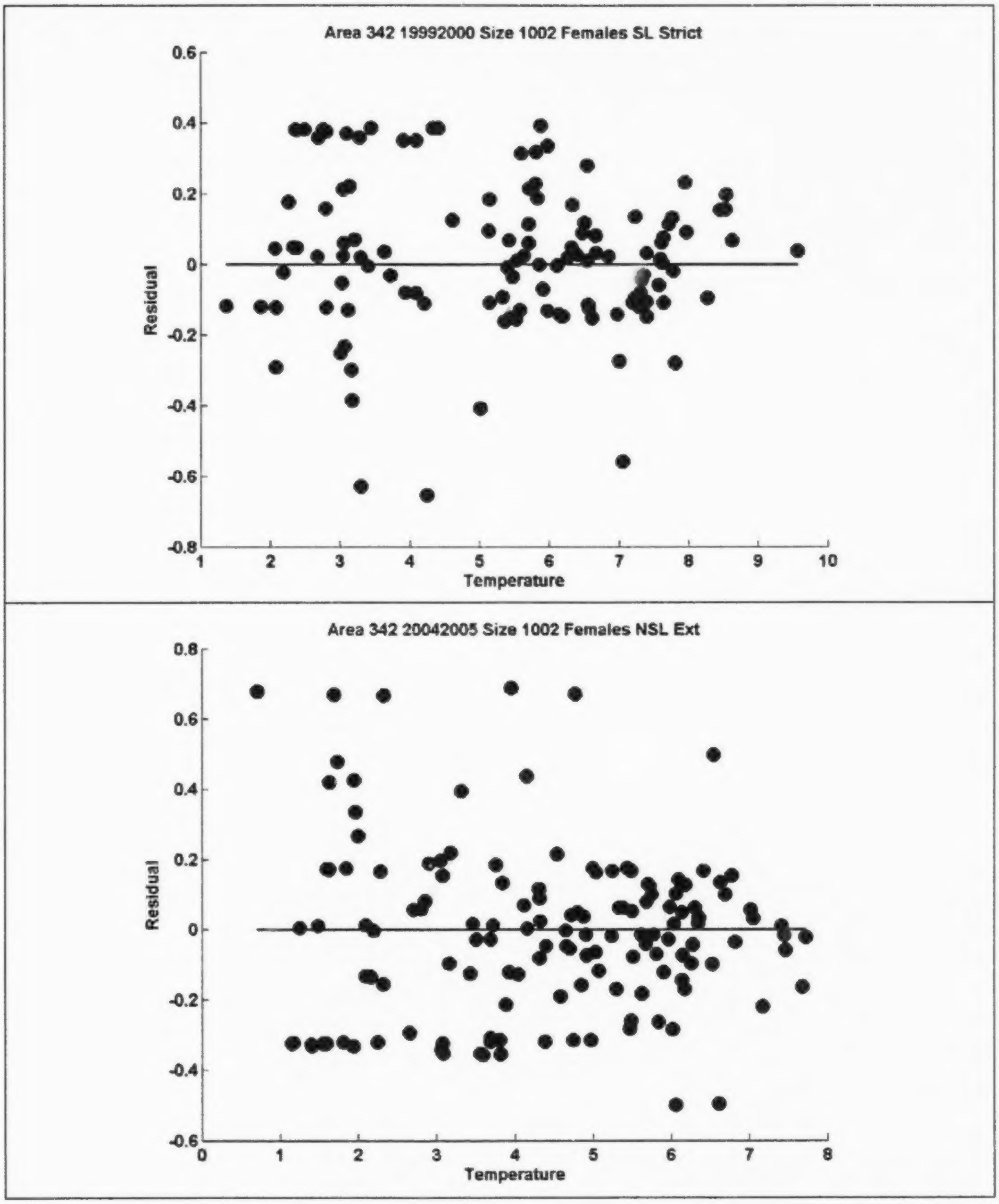


Figure 4.4.2f Observed ratio of reference to sum of reference + exploited lobster (closed circle) and estimated change in ratio (solid line) for indicated season and sex.


Area 342 19992000 Size 1002 Females SL Strict

Area 342 20042005 Size 1002 Females NSL Ext

Figure 4.4.2g Residuals versus temperature for change-in-ratio model for indicated seasons and sex.

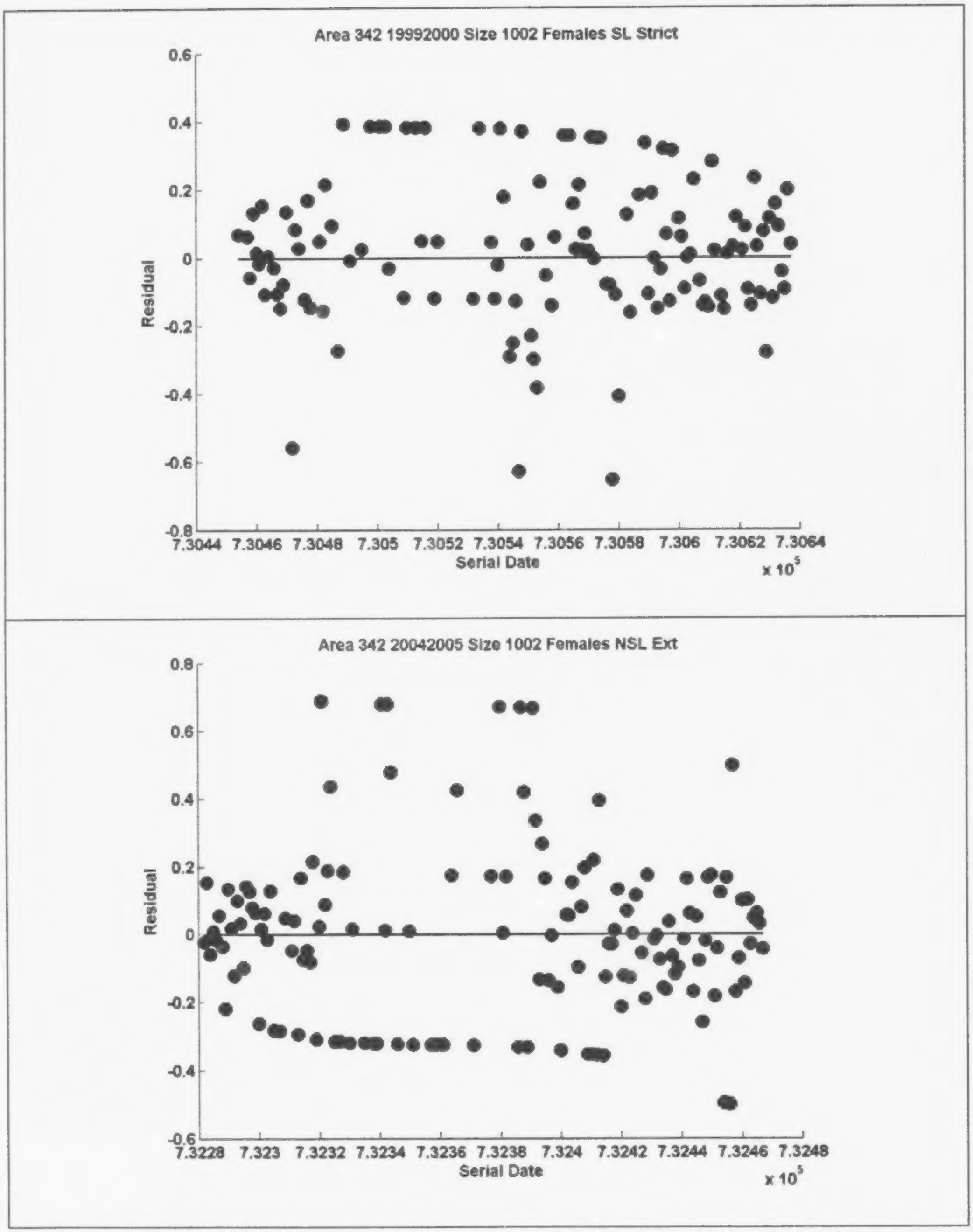


Figure 4.4.2h Residuals versus date for change-in-ratio model for indicated seasons and sex.

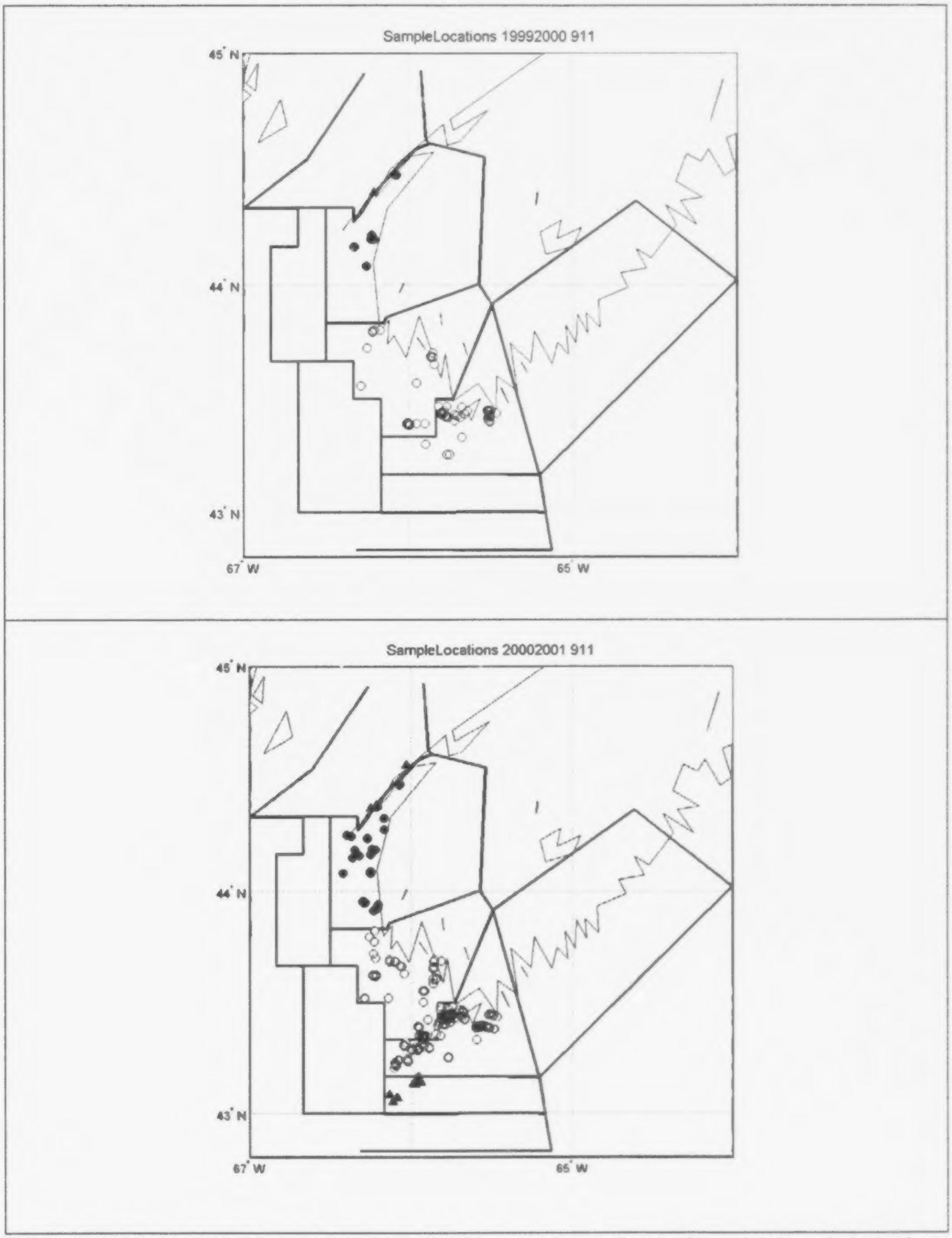


Figure 4.4.3 a 1999-00 and 2000-01 distribution of samples in Area 1 (closed circles), Area 2 (open circles), and Area 3 (triangles).

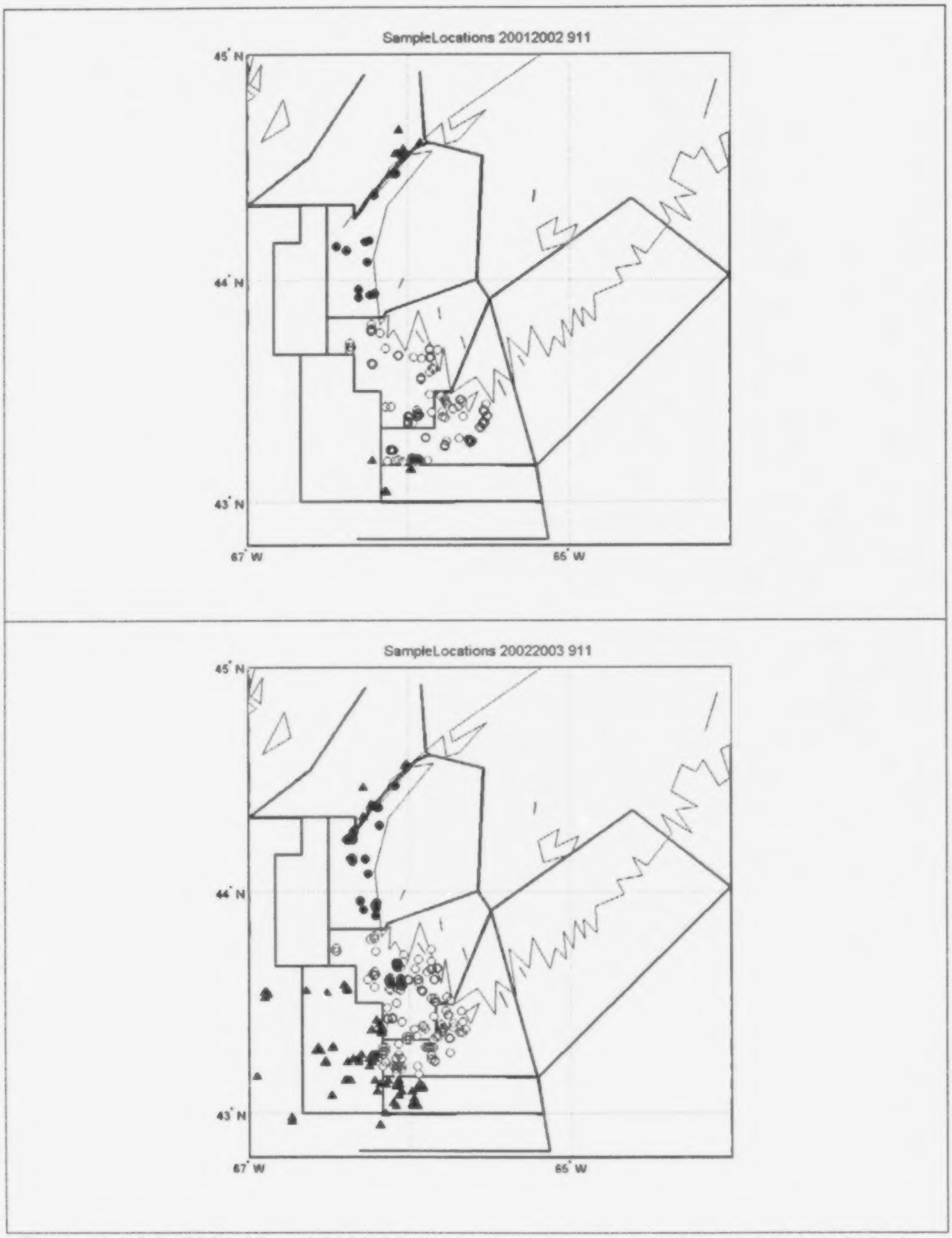


Figure 4.4.3 b 2001-02 and 2002-03 distribution of samples in Area 1 (closed circles), Area 2 (open circles), and Area 3 (triangles).

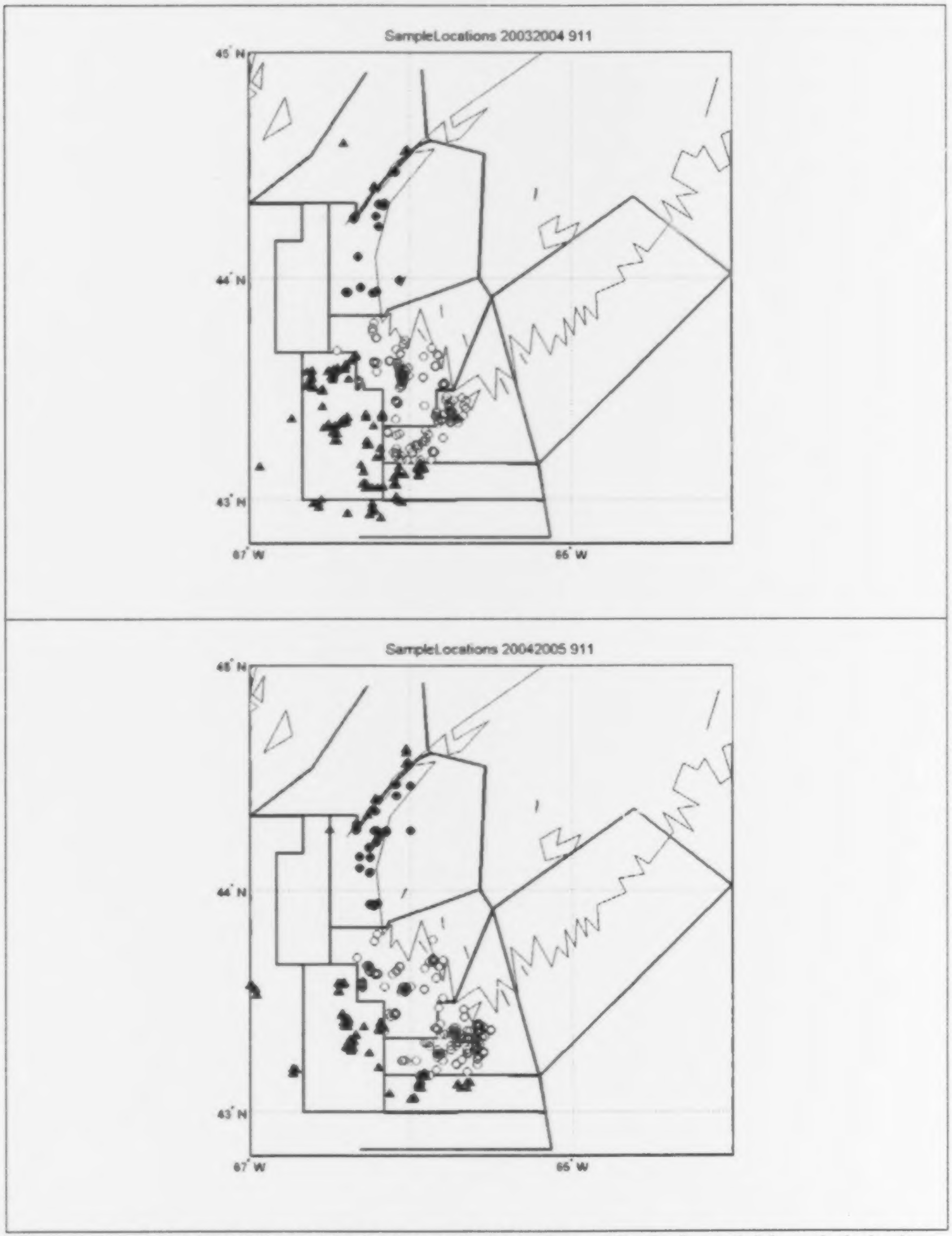


Figure 4.4.3 c 2003-04 and 2004-05 distribution of samples in Area 1 (closed circles), Area 2 (open circles), and Area 3 (triangles).

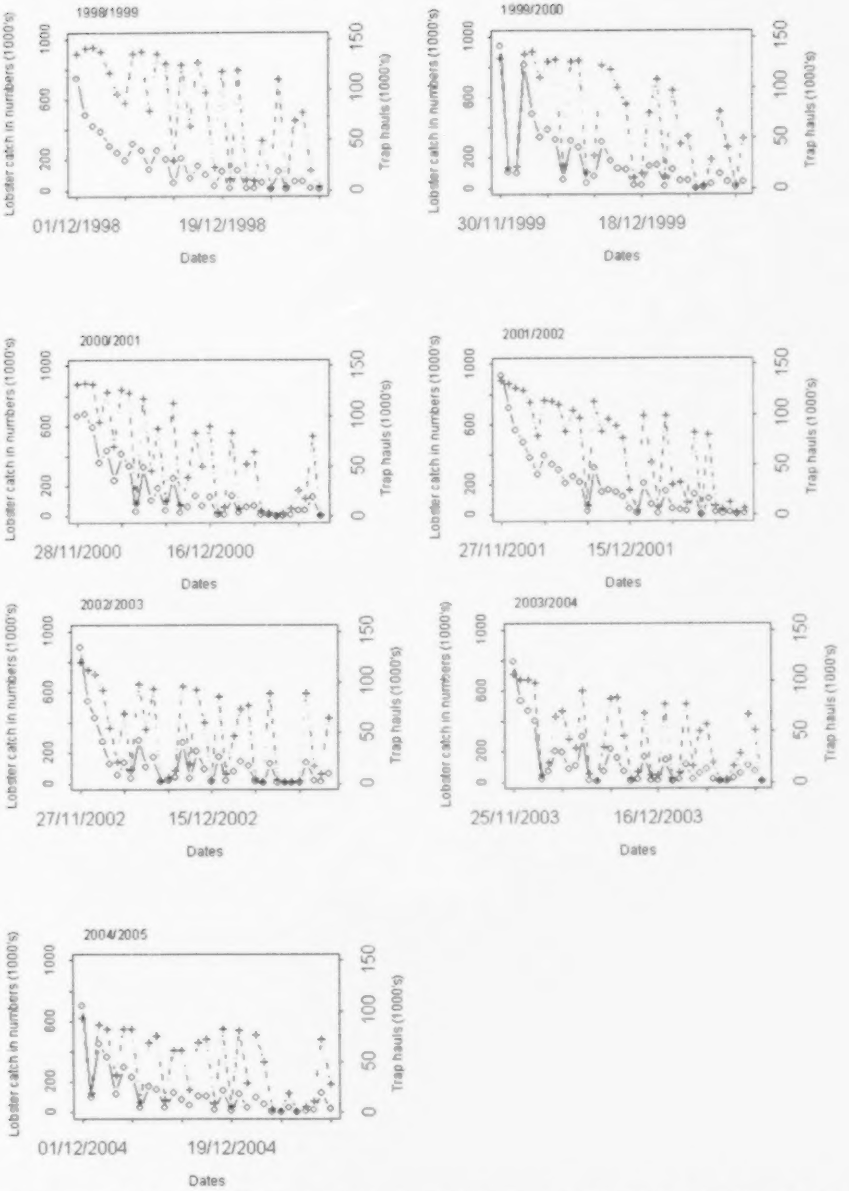


Figure 4.5.1 Daily catch rate and effort data from LFA 34 log books for the period starting at the beginning of the lobster fishery every year until December 31st the same year in the Lobster Bay area of LFA 34. Panels refer to fishing season. Solid lines and circles represent catch and dash-dot line with crosses represent effort.

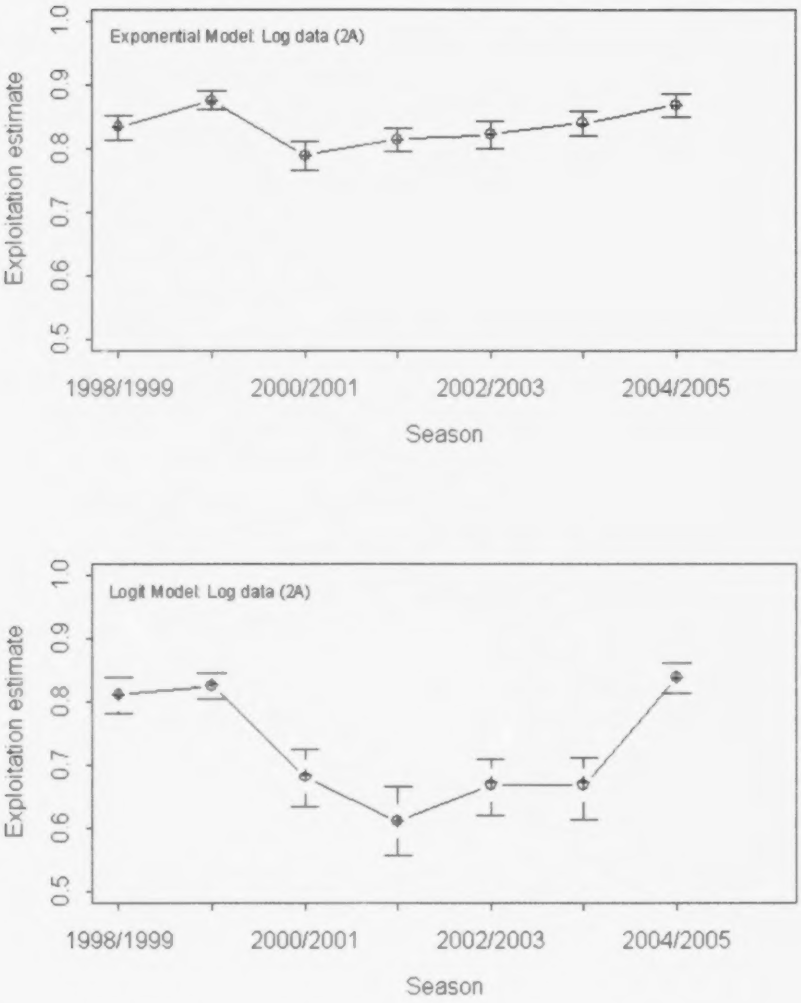


Figure 4.5.2 Exploitation estimates and 95 percent confidence intervals from Bayesian model of catch as a function of effort, for the exponential model (upper panel) and logit model (lower panel). Circle indicates posterior mean exploitation estimate and + indicates maximum likelihood estimate for comparison. Catch and effort data are from LFA 34 log books starting at beginning of season until December 31 the same year in the Lobster Bay area of LFA 34.

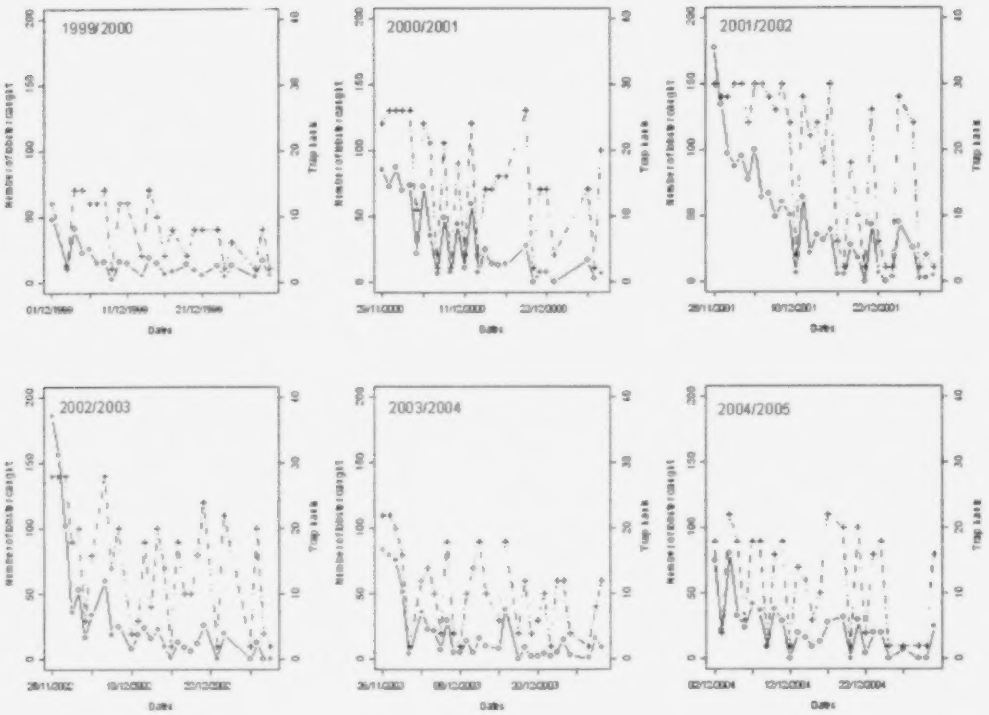


Figure 4.5.3 Daily catch rate and effort data from Fishermen Scientists Research Society (FSRS) fishing logs for the period starting at the beginning of the lobster fishery every year until December 31st the same year in the Lobster Bay area of LFA 34. Panels refer to fishing season. Solid lines and circles represent catch and dash-dot line with crosses represent effort.

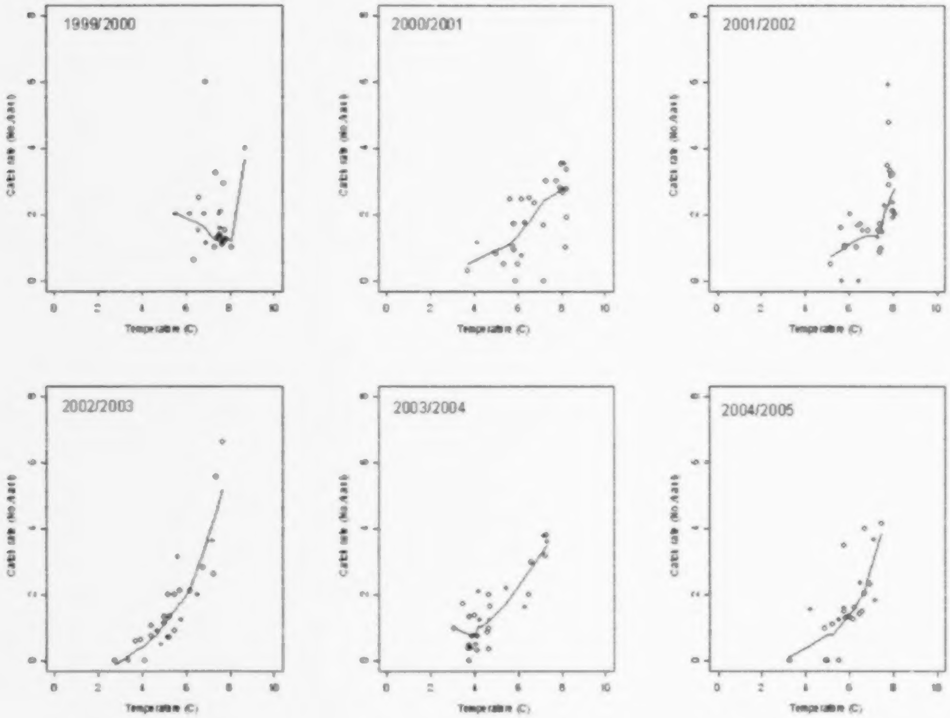


Figure 4.5.4 Catch rate (number of lobsters per trap haul) and temperature data from Fishermen Scientists Research Society (FSRS) fishing logs for the period starting at the beginning of the lobster fishery every year until December 31st the same year in the Lobster Bay area of LFA 34. Lines represent a LOESS fit to the data. Panels refer to fishing season.

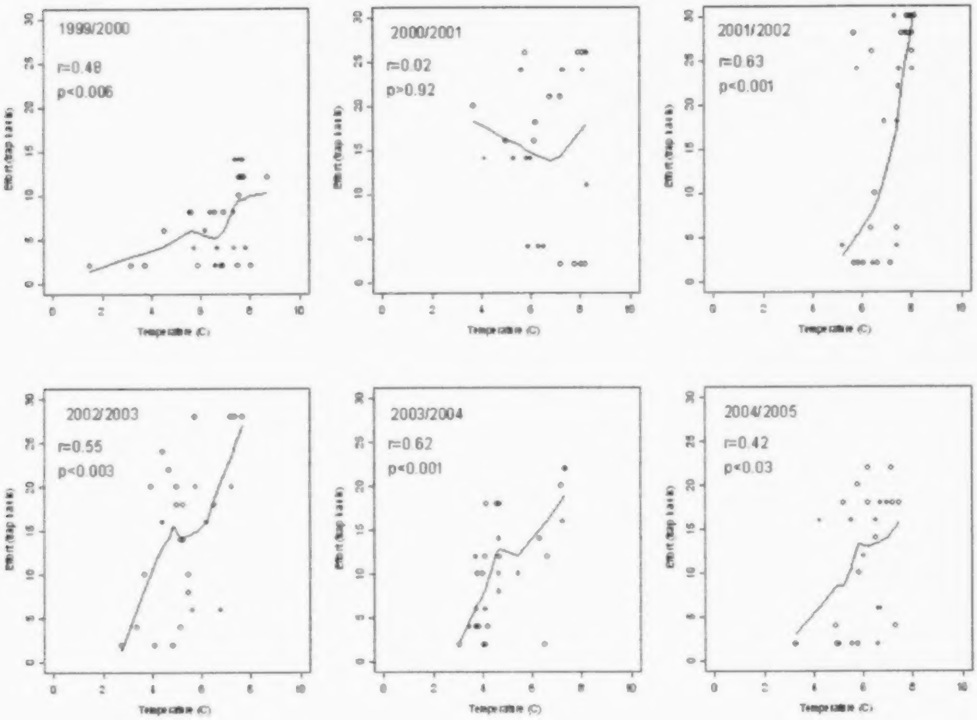


Figure 4.5.5 Effort and temperature data from Fishermen Scientists Research Society (FSRS) fishing logs for the period starting at the beginning of the lobster fishery every year until December 31st the same year in the Lobster Bay area of LFA 34. Panels refer to fishing season. The correlation coefficient (r) and the p-value for the test of whether r is significantly different from zero is given on each panel.

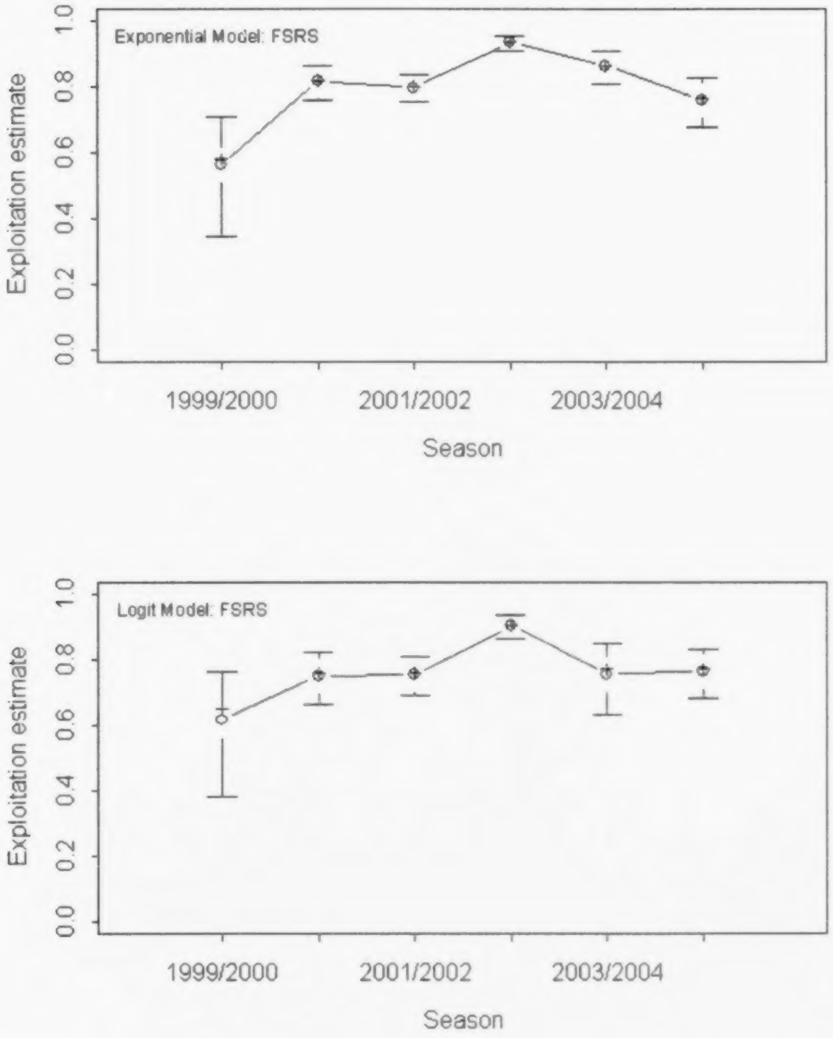


Figure 4.5.6 Exploitation estimates and 95 percent confidence intervals from Bayesian model of catch as a function of effort, for the exponential model (upper panel) and logit model (lower panel). Circle indicates posterior mean exploitation estimate and + indicates maximum likelihood estimate for comparison. Catch and effort data from Fishermen Scientists Research society (FSRS) lobster fishing logs starting at beginning of season until December 31 the same year in the Lobster Bay area of LFA 34.

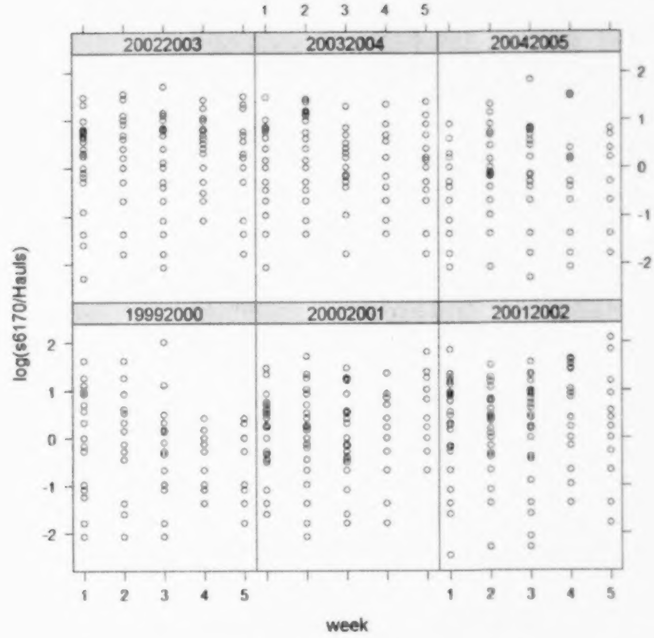


Figure 5.1.1 Log(No. per trap haul of 61-70mm CL) in FSRS traps, fall, grid 2ab.

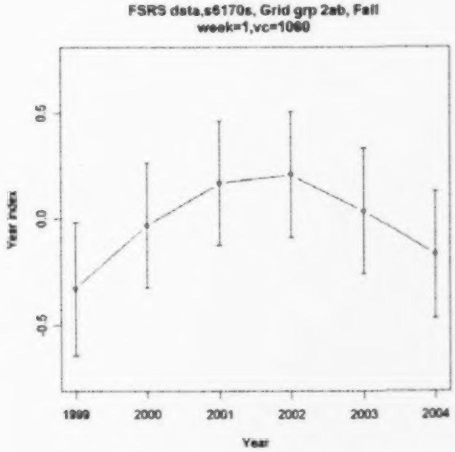


Figure 5.1.2 Cpue index and confidence intervals for lobster 61-70mm CL, Grid Group 2ab, fall. Derived from the model of log (no. per trap haul) on week, season and vesselcode fit without the global intercept. Index is standardized to week=1 and for a particular vesselcode.

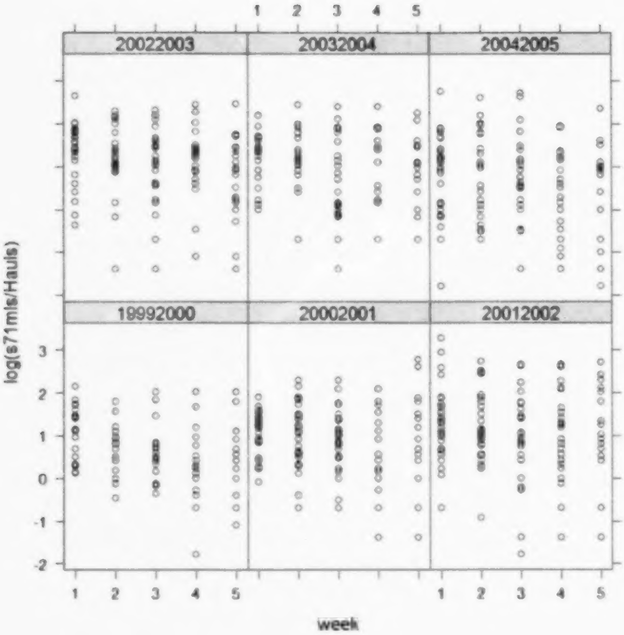


Figure 5.1.3 Log(No. per trap haul of 71mm CL to MLS) in FSRS traps, fall, grid 2ab.

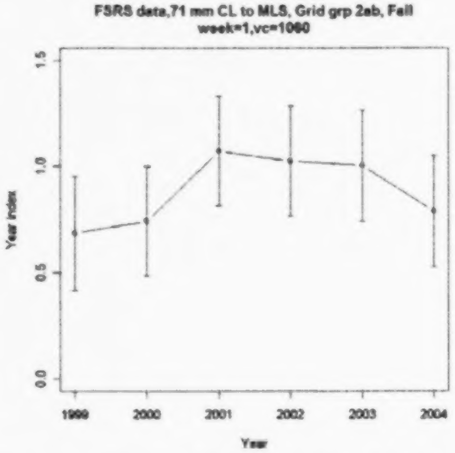


Figure 5.1.4 Cpue index and confidence intervals for lobster 71mm CL to the minimum legal size (MLS), Grid Group 2ab, fall. Derived from the model of log (no. per trap **haul) on** week, season and vesselcode fit without the global intercept. Index is standardized to week=1 and for a particular vesselcode.

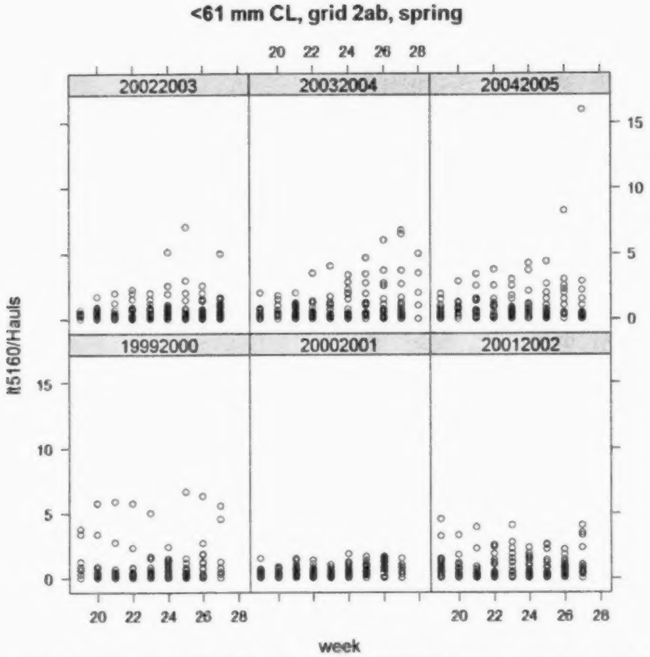


Figure 5.1.5 No. per trap haul of <61mm CL in FSRS traps, spring, grid 2ab. Note data are not logged as in other figures because of high proportion of zeros.

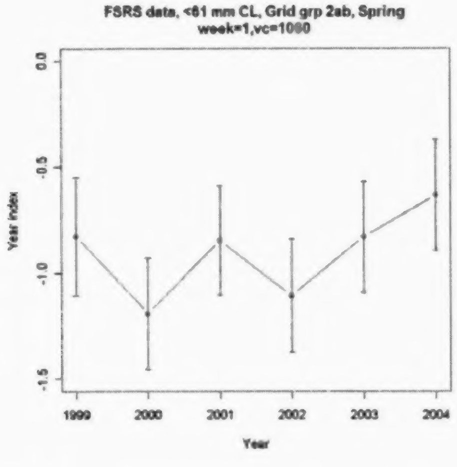


Figure 5.1.6 Cpue index and confidence intervals for lobster <61mm CL, Grid Group 2ab, spring. Derived from the model of log (no. per trap haul) on week, season and vesselcode fit without the global intercept. Index is standardized to week=1 and for a particular vesselcode.

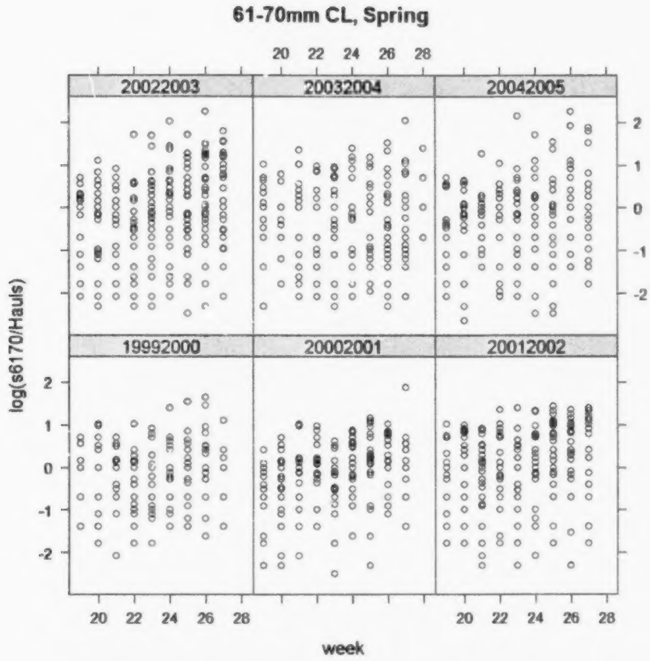


Figure 5.1.7 Log(No. per trap haul of 61-70mm CL) in FSRS traps, spring, grid 2ab.

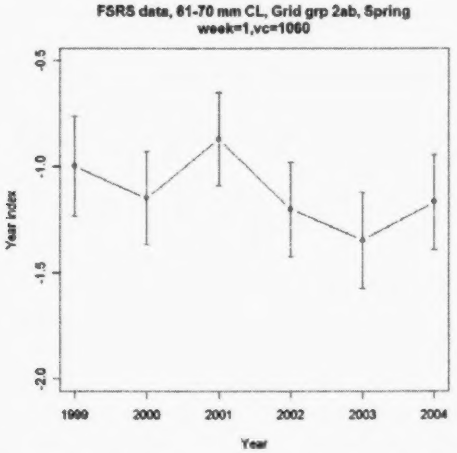


Figure 5.1.8 Cpue index and confidence intervals for lobster 61-70mm CL, Grid Group 2ab, spring. Derived from the model of log (no. per trap haul) on week, season and vesselcode fit without the global intercept. Index is standardized to week=1 and for a particular vesselcode.

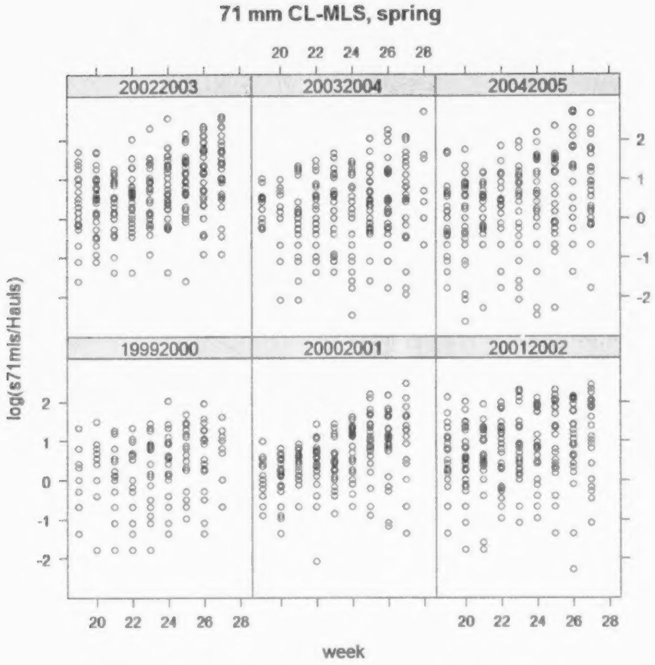


Figure 5.1.9 Log(No. per trap haul of 71mm CL to MLS) in FSRS traps, Grid Group 2ab, spring.

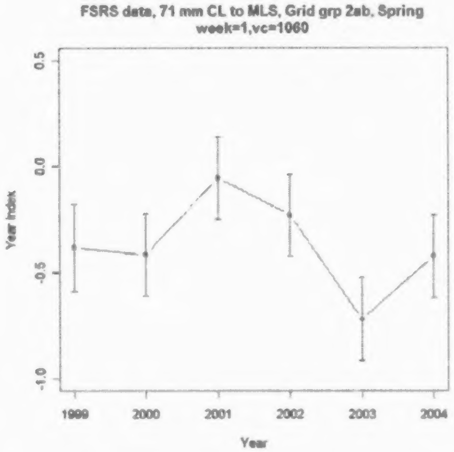


Figure 5.1.10 Cpue index and confidence intervals for lobster 71mm CL to MLS, Grid Group 2ab, spring. Derived from the model of log (no. per trap haul) on week, season and vesselcode fit without the global intercept. Index is standardized to week=1 and for a particular vesselcode.

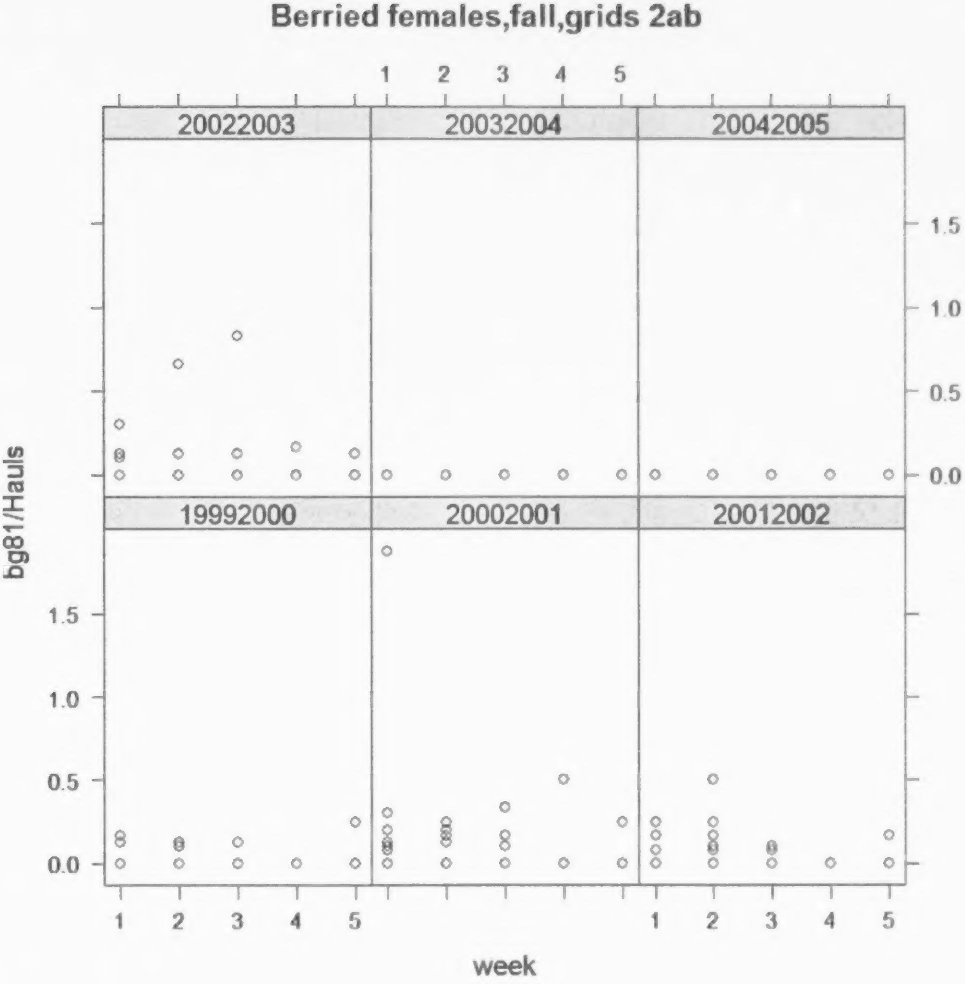


Figure 5.2.1 Number per trap haul of berried females >81mm CL in FSRS traps, Grid Group 2ab, fall.

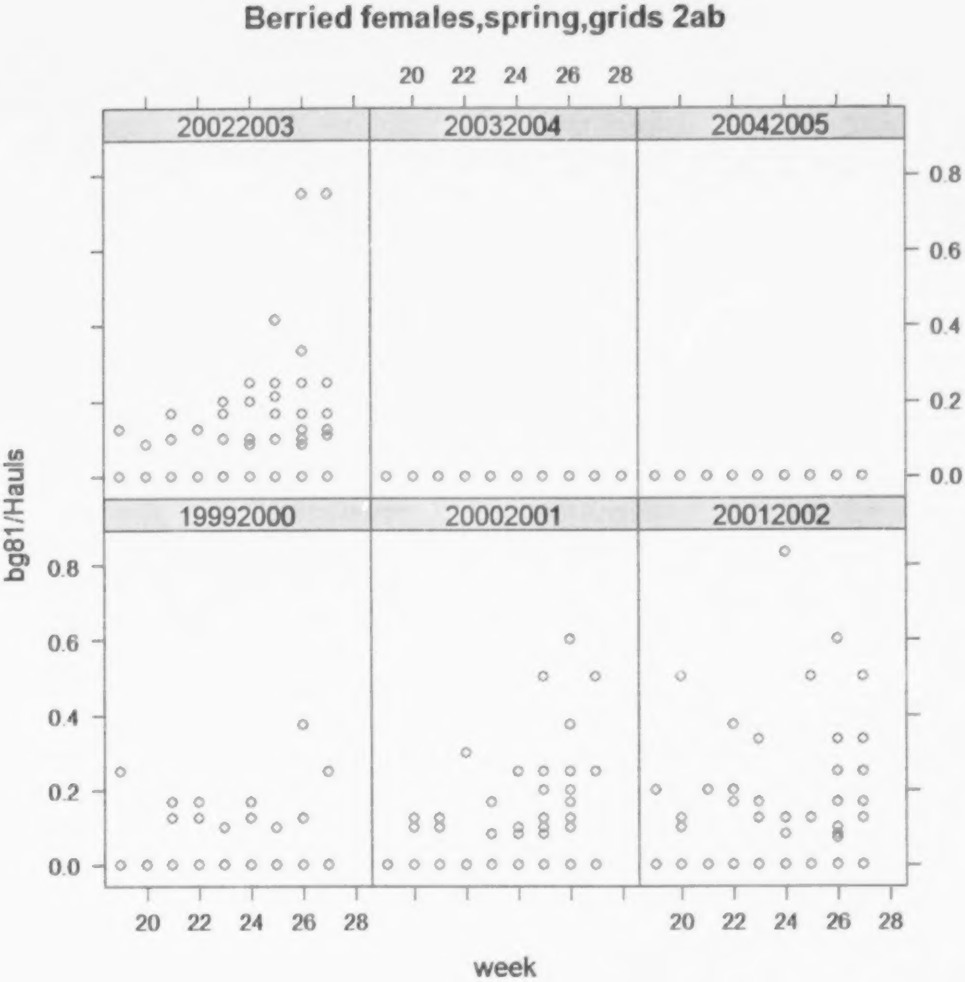


Figure 5.2.2 Number per trap haul of berried females >81mm CL in FSRS traps, Grid Group 2ab, spring.

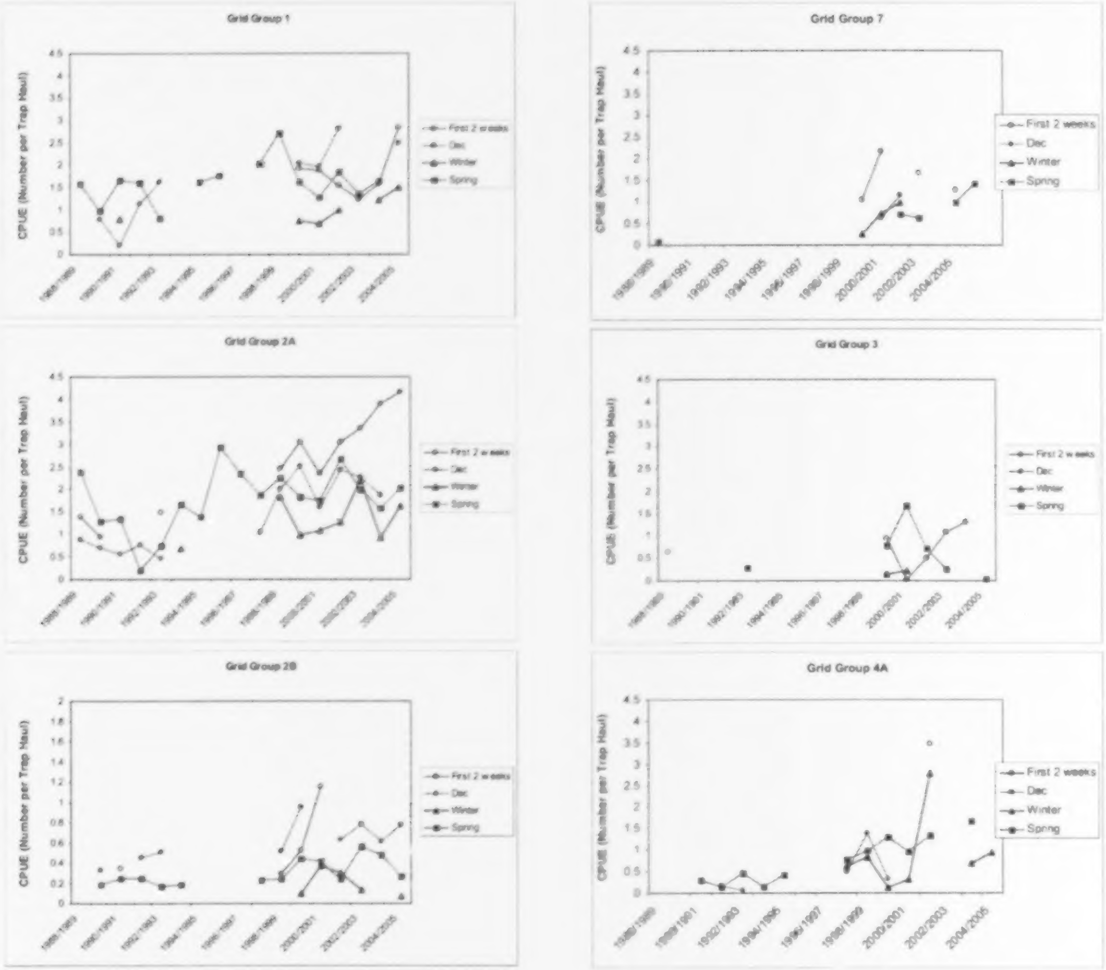


Figure 5.3.1 Catch rate of pre-recruits (70-79mm CL) from at sea samples by fishing period.

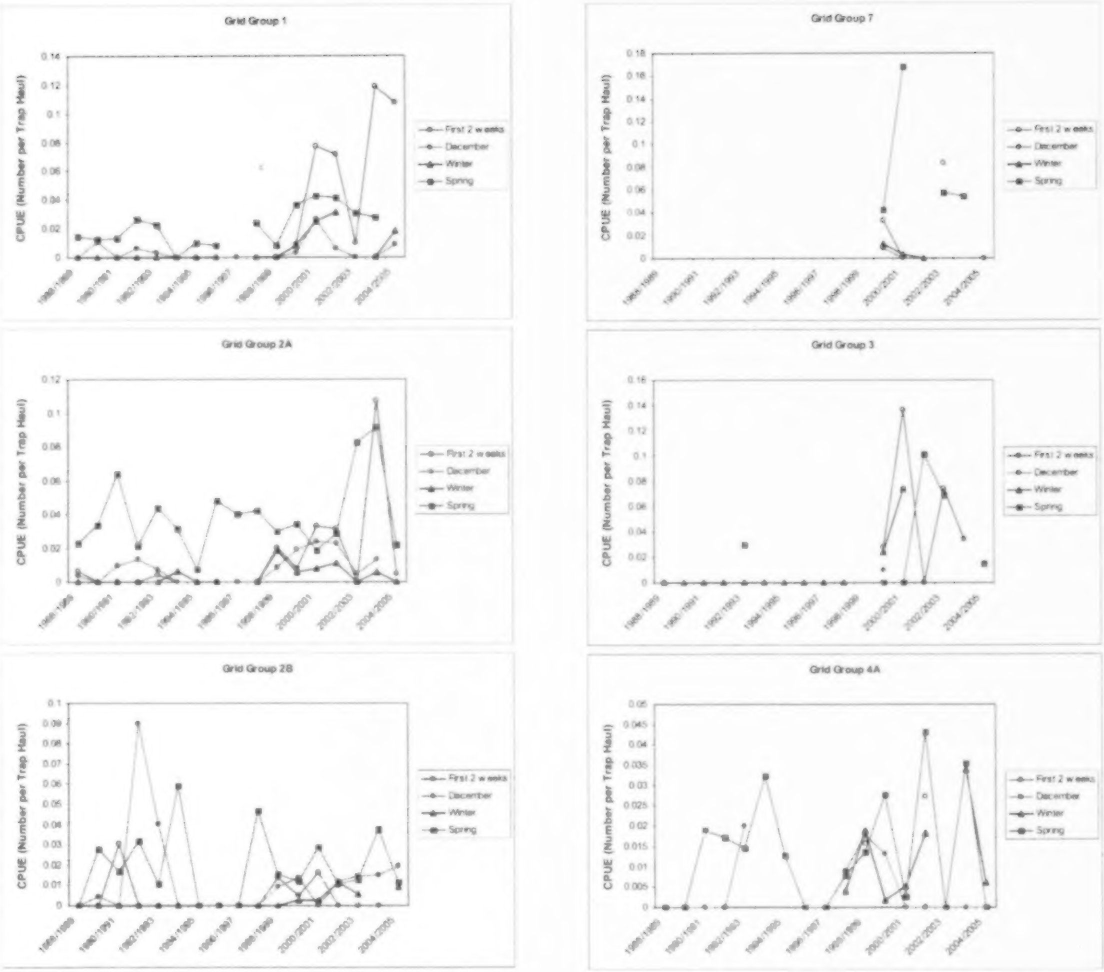


Figure 5.4.1 Catch rate of Berried females from at sea samples by fishing period.

Appendix 1 History of regulations LFA 34

LFA 34 Fishery Regulations and Methods					
Year	**Events in Fishery**	**Minimum Size/V-Notch**	**Seasons**	**Licenses**	**Gear**
1870's	Decreasing average size, first signs of over fishing (Venning 1973) **1878** -Development of live lobster trade in SW Nova Scotia	**1873** - no landing of soft shell or berned females minimum size 1.5 lbs. **1874** - 9" total (79mm CL) replaced 1.5lb minimum (approx. 94mm CL)	**1874 - 1879**: September - July (replaced prohibition on soft shelled lobsters)		Hoop Trap and shore gathering method
1880's	Poor enforcement and canning of short and berned lobsters common Decline began 1887-1918	**1887** - 79 mm CL	**1879 - 1887**: April - July (first attempt to reduce exploitation rates)		First box traps.. Aprrox. 75 - 90 traps/fisher
1890's	1887-1913- 8 Commissions to study fishery Hatcheries established	**1899** - 79 mm CL for Yarmouth/Shelburne County **1899** - 92 mm CL for Digby County	**1887 - 1900**: January - June		
1900's	Gasoline powered moterboats began replacing sail and row boats		November 30 - May 31 with small variations.. Currently last Monday in November - May 31		
1910's	1919- Hatcheries closed	**1910** - No size limit for Yarmouth/Shelburne County **1910** - 79 mm CL for Digby County		**1918** - license required, area unrestricted	**1910 - 1914**: 32 mm lath spacing. **1918** approx. 250 - 300 traps/fisher
1920's	Enforcement poor with large % of catch in some districts taken during closed season.				
1930's		**1934** - 78 mm CL		**1933** - fisher confined to one district in a given year	
1940's	Effort made to enforce size and seasons	**1941** - 79 mm CL		**1945**- use of vessel and gear resticted to one district in a given year	
1950's	Mass. increases minimum size and Canadian sizes adjusted to conform	**1952** - 81 mm CL			**1950 - 1955**: 41 mm lath spacing (rescinded in 1955 due to fishermen opposition and difficulty of enforcement)
1960's				**1968** - no new licenses, A & B licenses	**1968** - 375 trap limit, each trap tagged
1970's	**1972**- offfshore lobster district opened			**1973** - licenses confined to one district, **1976** - A, B & C licenses, **1978** - buyback	
1980's	**1988** USA size increased to 82.5mm CL Lobsters less than 82.5 mm CL restricted from USA live market				split trap limit , 375 Nov-march/ 400 April-May
1990's	FRCC report recommenting increased conservation	**1998/99** - V-Notching introduced			**1993** - 41 mm escape gaps and ghost panels 1999- issuing of 25 replacemnt tags to all fishers in spring
2000's		**1999 (Dec)** - 82.5 mm CL			